REEVALUATION OF THE STATUS OF PEARY CARIBOU AND MUSKOX POPULATIONS WITHIN THE BATHURST ISLAND COMPLEX, NORTHWEST TERRITORIES, JULY 1988

Frank L. Miller

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ABSTRACT. A reevaluation of the statuses of Peary caribou (Rangifer tarandus pearyi) and muskoxen (Ovibos moschatus) on the south-central Queen Elizabeth Islands was carried out by the Canadian Wildlife Service in 1988. An aerial survey to determine numbers and distributions of Peary caribou and muskoxen was flown between 11 and 21 July 1988. The survey area included the islands of Bathurst, Cornwallis, Vanier, Cameron, Alexander, Massey, Little Cornwallis, Helena and Marc, Northwest Territories, in the Canadian Archipelago. A systematic unbounded line transect survey was flown at about 90 m above ground level, air speed of about 160 $km \cdot h^{-1}$, along transects at 6.4-km intervals (on Bathurst, Cornwallis, Little Cornwallis and Helena) and at 3.2-km intervals (on Vanier, Cameron, Alexander, Massey and Marc). The survey aircraft was a Bell-206B turbo-helicopter on floats, equipped with a standard navigation system. A four-person survey crew was used. We saw 467 caribou and 346 muskoxen (1+ yr-old), 169 caribou calves, and 52 muskox calves during the survey. Numbers within the entire survey area were estimated at 1103 $\pm$ 146 (S.E.) caribou and 591 $\pm$ 113 (S.E.) muskoxen. Overall estimated mean densities were 4.1 $\pm$ 0.5 (S.E.) caribou $\cdot$ 100 km^{-2} and 2.2 $\pm$ 0.4 (S.E.) muskoxen $\cdot$ 100 km^{-2}. The estimated number of caribou was greatest on Bathurst Island but the highest mean density was estimated for caribou on Massey Island. Both the estimated number and the estimated mean density of muskoxen were greatest on Bathurst Island. Caribou calves represented 26.6% of all caribou and muskox calves 13.1% of all muskoxen seen on and off survey. All findings in 1988 indicate that numbers of Peary caribou and muskoxen apparently have increased measurably within the nine-island, south-central Queen Elizabeth Islands complex (the Bathurst Island complex) over the levels reported for summer 1974. However, the 1988 estimates for Peary caribou and muskoxen within the Bathurst Island complex remain well below the 1961 estimates at about 30% and 49%, respectively. The number of Peary caribou summering within the 1988 survey area would not safely support essentially any appreciable level of sustained annual harvest, especially if it involved the removal of females and particularly breeding age females. If a token harvest is sought, it is recommended that it be restricted to a low (10 or less) number of males.

RÉSUMÉ. En 1988, le Service canadien de la faune a réévalué la situation du caribou de Peary (Rangifer tarandus pearyi) et du boeuf musqué (Ovibos moschatus) dans le centre-sud des îles de la Reine-Elisabeth. Un dénombrement aérien effectué entre le 11 et le 21 juillet 1988 a permis d'estimer l'effectif et la distribution des caribous de Peary et des boeufs musqués. La région à l'étude incluait les îles Bathurst, Cornwallis, Vanier, Cameron, Alexander, Massey, Little Cornwallis, Helena et Marc, dans les Territoires du Nord-Ouest, dans l'archipel Arctique. Un relevé systématique par transects linéaires illimités a été effectué à environ 90 mètres-sol, à une vitesse d'environ 160 $km.h^{-1}$, le long de transects distants de 6,4 km (dans les îles Bathurst, Cornwallis, Little Cornwallis et Helena) et de 3,2 km (îles Vanier, Cameron, Alexander, Massey et Marc). L'appareil utilisé était un hélicoptère turbo Bell-206B à flotteurs, équipé d'un système de radionavigation standard. L'équipage était composé de quatre personnes. Au cours du relevé, 467 caribous et 346 boeufs musqués (1 an^{+}), 169 faons et 52 veaux ont été dénombrés. La population de caribous et de boeufs musqués a été estimée respectivement à 1 103 ± 146 (erreur-type) et 591 ± 113 (erreur-type) dans toute la région à l'étude. Les densités moyennes estimées étaiemt de 4,1 ± 0,5 (erreur-type) caribous · 100 km^{-2} et de 2,2 ± 0,4 (erreur-type) boeufs musqués · 100 km^{-2}. La plus grande population estimée de caribous a été relevée dans l'île Bathurst, mais la plus forte densité moyenne a été relevée dans l'île Massey. C'est dans l'île Bathurst que la population et la densité moyenne estimées de boeufs musqués ont été les plus fortes. Les faons constituaient 26,6 % de tous les caribous, et les veaux 13,1 % de tous les boeufs musqués observés à différentes reprises au cours du relevé. Les données rassemblées en 1988 révèlent que les effectifs de caribous de Peary et de boeufs musqués ont apparemment augmenté notablement dans les neuf îles et le centre-sud des îles de la Reine-Elisabeth (complexe de l'île Bathurst) par rapport à l'été 1961. Toutefois, les chiffres de 1988 sont restés bien inférieurs à ceux de 1961, soit de 30 % pour les caribous de Peary et de 49 % pour les boeufs musqués du complexe de l'île Bathurst. Selon les estimations, la population de caribous de Peary passant l'été dans la région à l'étude en 1988 ne pourrait survivre à une chasse annuelle soutenue, notamment si des femelles et plus particulièrement des femelles en âge de se reproduire sont tuées. S'il faut établir un quota, il est recommandé de le fixer à un petit nombre de mâles (10 au plus).

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INTRODUCTION

The Peary caribou (Rangifer tarandus pearyi) is now found regularly only in the Canadian High Arctic. No viable populations of Peary caribou currently exist in Greenland (Meldgaard 1986) and Peary caribou are not known from Alaska or any Paleoarctic location. Thus, the Peary caribou is a socially important, economically valuable, unique form of wildlife in the natural heritage of arctic Canada. Recognition of Peary caribou as a "Threatened" form of wildlife in Canada (Gunn, Miller, and Thomas, COSEWIC, 1979; or see Gunn et al. 1981) makes the conservation and preservation of Peary caribou a responsibility of Environment Canada and more specifically the Canadian Wildlife Service under the Canada Wildlife Act.

The Canadian Wildlife Service initiated a reevaluation of the status of Peary caribou in the Canadian High Arctic in 1985, because a decade had passed since the last extensive aerial surveys of Peary caribou were carried out (Miller et al. 1977a). Due to limited resources the program required 3 years and aerial surveys were restricted to the major islands of Melville, Bathurst and Prince Patrick and their associated satellite islands (Miller 1987a, 1987b, 1988).

The muskox (Ovibos moschatus) is the only other ungulate that occurs regularly in the Canadian High Arctic and is an important element in the arctic ecosystem. Both Peary caribou and muskoxen are the major and likely the sole staples in the diet of the high arctic wolf (Canis lupus arctos); thus, the abundance of each prey species relative to each other likely influences the levels of predation experienced by each species. Therefore, muskoxen are monitored along with Peary caribou whenever possible.

Eleven of the 26 Queen Elizabeth Islands that exceed 400 km^2 in size were resurveyed by air in summers 1985-87. Those 11 islands were chosen because when first aerially surveyed in summer 1961 (Tener 1961, 1963) they held nearly four-fifths (78.6%) of the 25 845 Peary caribou estimated on the Queen Elizabeth Islands; although those 11 islands represent only about 20% of the entire landmass of the Queen Elizabeth Islands. Subsequently, the number of Peary caribou estimated on those 11 islands had declined nearly 75% to 5186 in summer 1973. Then, after the catastrophic die-offs in winter 1973-74, the summer 1974 estimate was only about 13% (2597) of the 1961 estimate. Finally, when the 11 islands were last surveyed in summers 1985-87, the estimated number of Peary caribou had declined by over 90% from 1961 to only 2015 caribou. Thus, the most recent survey results indicate that Peary caribou in the Canadian High Arctic have been in an apparently continual overall decline for at least 26 years (1961-1987).

However, findings from the Bathurst Island complex in 1985 (estimated 727 ± 138 (S.E.) caribou) suggested an increase in the number of Peary caribou within the complex from 1974 (Miller et al. 1977a, Miller 1987a) and was contrary to the trend for all other islands surveyed in 1986 and 1987 (Miller 1987b, 1988). Therefore, the numbers and distributions of Peary caribou within the Bathurst Island complex were remeasured in summer 1988 to help verify and better evaluate the accuracy of the 1985 results. Also, the numbers of Peary caribou on Cornwallis and Little Cornwallis islands and the small islands of Barrow Strait (Browne, Garrett, Griffith, Hamilton, Lowther, Somerville and Young), Intrepid Passage (Baker and Moore) and McDougall Sound (Crozier, Kalivik, Milne, Neal and Truro) were determined to maximize the accuracy of the 1988 reevaluation of the Bathurst Island complex. The following is a report of those findings.

STUDY AREA

1. Islands

The nine south-central Queen Elizabeth Islands surveyed in July 1988 lie between latitudes 74° and 77°N and longitudes 93° and 105°W (Figs. 1 and 2). Total landmass of the islands surveyed is about 27 000 km^2. The survey area is mostly low-lying and mainly below 150 m above mean sea level (amsl) in elevation.

1.1. Bathurst Island (75°50'N, 99°30'W)

Bathurst Island is the largest island (16 090 km^2) in the 1988 survey area (Fig. 1), and has a distinctive pattern of inlets and intervening ridges and headlands which reflect the underlying geology (Fortier et al. 1963). Most of the coast is sharply sloping, and rugged, but with few cliffs. Because of the long inlets, 25% of the land surface is within 2.5 km of the coast.

The topography of the northern three-quarters of Bathurst Island is dominated by east-northeast folds of bedrock, which form ridged uplands. Erosion has caused regular and continuous ridges with gentle to moderately steep slopes. The drainages either follow the main valleys or cut across ridges forming a trellis pattern. Most of the land (62%) is below 150 m amsl in elevation, and the greatest relief is on the northwest, where bluffs reach 412 m amsl.

The southern quarter of Bathurst Island is mainly a gently undulating plateau mostly below 60 m amsl with few well-defined features. The land is less well-drained than the

upland ridges to the north. To the southwest the plateau surface is more dissected with many small ponds.

About 24% of Bathurst Island lies below 60 m amsl. Ground elevations vary considerably among the three survey strata. Most of the terrain below 60 m amsl occurs in St. III (5360 km^2). St. II (6650 km^2) has about 75% more intermediate and high ground than St. I (4080 km^2) or III.

1.2. Cornwallis Island (75°10'N, 94°50'W)

Cornwallis Island is of intermediate size (7000 km^2); however, the island (Fig. 2) with a few small exceptions has sparse, often absent, vegetation (Thorsteinsson 1958, Tener 1963). The only two major (40-60 km^2 each) exceptions to the above are the river drainages of Eleanor Lake in the northeast and the most westerly large drainage valley in the southwest of the island, which are relatively well-vegetated.

1.3. Ile Vanier (76°10'N, 103°30'W)

Ile Vanier (Fig. 1) is the largest (1130 km^2) of the group of islands known as the Governor General Group. Like northern Bathurst and the other islands in the group, the topography is dominated by folded upland, with ridges and hills running east-northeast. About one-third (348 km^2) of Vanier is between 150 m and 259 m amsl in elevation. The higher land includes the central Adam Range with a maximum elevation of 259 m amsl. The shoreline is relatively steep with well marked coastal terraces and a narrow coastal plain.

1.4. Cameron Island (76°30'N, 103°50'W)

The folded upland that dominates the topography of the islands in the Governor General Group is only evident on the southeast of Cameron Island (1060 km^2), where only 0.6% of the area is above 150 m amsl and reaches a maximum height of 193 m amsl (Fig. 1). North and west across the island is a sloped and scarped lowland.

1.5. Alexander Island (75°50'N, 102°40'W)

Alexander Island is similar in size (490 km^2) to Massey but lower in elevation (Fig. 1). The 2% of land (11 km^2) above 150 m amsl is mostly in the east where the land rises to 198 m amsl.

1.6. Massey Island (76°00'N, 103°10'W)

Less than half the size (440 km^2) of and lower in elevation than Ile Vanier, Massey Island is similar in relief and geological structure (Fig. 1). Only 12% (55 km^2) of the land is above 150 m amsl with a maximum elevation of 210 m amsl.

1.7. Little Cornwallis Island (75°30'N, 96°20'W)

Little Cornwallis is a small (410 km^2) irregularly shaped island, divided into two parts by a low narrow isthmus (Fig. 2). The coast is low; inland are about 15 lakes separated by low knobby hills, the highest of which is 137 m amsl.

1.8. Helena Island (76°40'N, 101°10'W)

The Berkley Group of islands lie about 10 km north of Bathurst (Fig. 1). The largest island is Helena with an area of 220 km^2 of which 40% (132 km^2) is above 150 m amsl. The land rises steeply from the south coast to a maximum of 282 m amsl and slopes gently to the north.

1.9. Ile Marc (75°50'N, 103°40'W)

Ile Marc is a small (56 km^2), flat, featureless island, below 150 m amsl (Fig. 1).

2. Islands Aerially Searched

Fourteen small islands that are known to (e.g., Bissett 1968, Miller et al. 1977a, Miller and Gunn 1978, 1980) or likely to receive migrant caribou from Bathurst Island during periods of springtime environmental stress were included in the study area (Figs. 3 and 4). All of these islands are poorly vegetated and none is of a size that could support any significant number of Peary caribou on a year-round basis. However, because of their exposed nature these small islands could collectively provide, and sometimes have provided, valuable temporary relief for caribou fleeing widespread forage unavailability within the Bathurst Island complex. These 14 small islands collectively total about 370 km^2 and include seven in Barrow Strait (Browne, Garrett, Griffith, Hamilton, Lowther, Somerville and Young), five in McDougall Sound (Crozier, Kalivik, Milne, Neal and Truro) and two in Intrepid Passage (Baker and Moore).

3. Climate

The climate of the survey area is characterized by long cold winters, short cool summers and low precipitation. Air temperatures average below -17.7°C from December to March. Mean daily temperatures do not rise above 0°C until after 1 June on the extreme south of the survey area, and 15 June on the rest of the survey area (Meteorological Brancn 1970). The snow cover usually starts to melt in early June, and rapidly dissipates to bare ground by mid June, except for snowbanks in sheltered sites (Potter 1965). Summer is the period when the ground is generally snow free, and lasts from the beginning of July to the end of August. Winter starts when the mean daily temperature falls below 0°C usually about 15 September. September and October are the stormiest months and much of the annual snowfall may occur in those months. From December to March anticyclones dominate the weather causing frequent calms, clear skies and light snowfall.

Thompson (1971) compared 1 year's weather data from the National Museum of Science research station in Polar Bear Pass on central Bathurst Island to data from Resolute Bay. Her results suggested that the differences in the weather between the two locations were the result of the research station's inland site and local topographical effects. The Atmospheric Environmental Service weather station at Mould Bay, Prince Patrick Island, tends to have cooler, drier and less stormy weather than the weather station at Resolute Bay, Cornwallis Island.

The amount and duration of snow cover, especially in spring, are critical to arctic ungulates, but also critical are the types of snow cover and incidences of freezing rain. Wind removes the snow from exposed slopes and redeposits it as shallow but hard compacted cover and drifts in more sheltered and relatively well-vegetated sites. Freezing rain in autumn which results in ground fast ice before snow cover accumulates; ice layering in the snow; crusting of the snow; and the formation of ground fast ice in spring (e.g., Miller et al. 1982) compounds the stress of forage unavailability on arctic ungulates. Unfortunately neither the type of snow cover nor the incidence of ground fast ice or ice layering is available for the Queen Elizabeth Islands.

METHODS

1. Systematic Aerial Survey

1.1. Aircraft

A Bell-206B (Jet Ranger) turbo-helicopter on floats was used as the survey aircraft in July 1988.

1.2. Observers

I used a 4-person survey crew: pilot-navigator-spotter (right front seat); navigator-spotter (left front seat); and a left and a right rear seat observer. The survey crew communicated by use of a voice activated intercommunication system. The helicopter pilot navigated the line transects by making visual reference checks with 1:250 000 topographical maps. The navigator-spotter navigated visually with a separate set of 1:250 000 map sheets; recorded each observation by consecutive numbering (within each stratum); and called out the number for each observation to the rear seat observers. Both the pilot and the navigator also served as spotters and alerted the rear seat observers to the sighting of animals. If one of the rear seat observers was first to see animals, he called out his sighting to alert the other crew members. The rear seat observer on the side of the helicopter where the animals were located recorded the details of the observation in a field notebook: (1) date; (2) stratum number; (3) transect number; (4) observation number; (5) degrees of angle obtained with hand held clinometer; (6) species and composition of animals sighted, as bulls, calves, and/or others (recorded initially as cows, juveniles, yearlings); and (7) remarks, if any. The animal(s) sighted were circled, if necessary, to determine their number and/or sex and age composition (all 4 crew members participated in the determinations).

1.3. Altitude

Altitude was maintained, as best possible, at about 90 m above ground level (agl) during the survey. Altitude was measured with a standard aviation altimeter (pressure type) in units of 6.1 m (20 ft).

1.4. Helicopter speed

The air speed of the helicopter was held at about 160 km $\cdot$ h^{-1}. Air speed was read from the aircraft air speed indicator.

1.5. Angle of animal(s) sighting

Each angle from the animal(s) to the helicopter was indirectly measured in degrees with a hand held clinometer (Suunto Co., Helsinki, Finland). The actual angle obtained was the angle of depression from the horizontal plane of the inflight helicopter to the animal(s) (Fig. 5). Thus, when the height of the helicopter is supposedly known; distance along a horizontal plane (supposedly at ground level) to the animal(s) from the point where the vertical projection of the centre of the helicopter

theoretically touches the ground can be obtained from the simple trigonometric function involving the tangent of an acute angle.

Given

(1) A right-angled triangle (ACB) is formed by joining (A) the helicopter, (B) the location of the animal(s) on the ground, and (C) the intercept of a horizontal plane from (A) with a vertical leg from (B) (Fig. 5).

(2) Side (CB) (Fig. 5) = (a) = vertical distance from animal(s).

(3) Side (AC) (Fig. 5) = (b) = horizontal distance from helicopter.

(4) Hypotenuse (AB) (Fig. 5) = (c) = diagonal leg from helicopter.

(5) Alpha (α) angle (BAC) is the acute angle of depression measured with a hand held clinometer by an observer (Fig. 5).

Assumptions

(1) Length (a) (Fig. 5) is equal to the height of the helicopter above ground level.

(2) Length (b) (Fig. 5) is equal to the horizontal distance from the helicopter to the animal(s).

Since $\quad \text{Tangent } \alpha = \frac{a}{b}$

Therefore $\quad b = \frac{a}{\text{Tan } \alpha}$

1.6. Survey design

I used a systematic, unbounded line transect type, aerial survey to obtain numbers and distributions of Peary caribou and muskoxen. Evenly spaced north-south line transects were drawn directly onto 1:250 000 topographical map sheets. Transects were drawn at 6.4-km intervals from a baseline at 99°W on Bathurst and Helena islands; at 6.4-km intervals from 95°W on Cornwallis and Little Cornwallis islands; and at 3.2-km intervals from 104° on Alexander, Marc, Massey, Vanier and Cameron islands. Selection of

a baseline was done mainly as a technical consideration to allow connection of each cross (+) indicator at each 15 minutes of one degree of latitudinal change along that meridian to maximize the subsequent accuracy of ruling off transect lines. These indicators appear as crosses (+) for each 15 minutes of latitude and each full degree of longitude in a grid pattern over each entire 1:250 000 Geological Survey of Canada topographical map sheet.

Bathurst Island was divided into three nearly equal sized survey land strata after Miller et al. (1977a) and Miller (1987a) on Geological Survey of Canada 1:250 000 topographical map sheets (Fig. 1). The area of each stratum was determined with a planimeter. St. I and II were separated on land by an arbitrary line drawn from the eastern side of the southernmost projection of Dundee Bight (99°54'W) in the north, south-southeasterly to the north shore of Bracebridge Inlet (99°50'W). There was no common land boundary between St. I and III. St. II and St. III were separated on land by an arbitrary line from the mouth of the river that empties into Goodsir Inlet on the east, westward across the lowlands of Polar Bear Pass to the most easterly edge of Bracebridge Inlet. Major western satellite islands of Bathurst Island were each considered as a separate survey stratum: Alexander, St. IV; Marc, St. V; Massey, St. VI; Vanier, St. VII; and Cameron, St. VIII (Fig. 1). Helena Island, the major northern satellite island of Bathurst Island, was considered as survey St. IX (Fig. 1). Little Cornwallis Island, interjacent to Bathurst and Cornwallis islands, was considered as St. X (Fig. 2). The most easterly island surveyed was Cornwallis Island and it was considered as St. XI (Fig. 2).

1.7. Statistical Methods

Density and population estimates as well as their variance estimates and 95% confidence intervals were made for both caribou and muskox populations in all survey strata. The probability $P < 0.05$ was the level of acceptance for significant relationships reported in this study.

The following symbols are used in the estimation procedures that follows.

N = the number of possible transects in the survey area.

n = the number of these N transects that are sampled.

f = n/N, the sampling fraction.

y_i = the number of animals counted on the i'th sampled transect.

x_i = the area of the i'th sampled transect.

Y = the true population of animals in the survey area.

$\overline{Y}$ = the mean number of animals per transect on all N transects.

$\overline{X}$ = the mean area of all transects.

A = total area.

R = the true mean density of animals in the survey area,

$$R = \overline{Y}/\overline{X}$$

$d_i = y_i - \hat{R}x_i$ where $\hat{R}$ is an estimator of R.

The standard estimator for the true mean density R is the ratio estimate:

$$\hat{R} = \frac{\sum_{i=1}^{n} y_i/n}{\sum_{i=1}^{n} x_i/n} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i} = \frac{\overline{y}}{\overline{x}}$$

where $\overline{y}$ = the mean count of animals on the sampled transects, and $\overline{x}$ = the mean area of the sampled transects.

Following the methods described by Kingsley and Smith (1981) an estimate of the variance of R is found by:

$$\hat{V}(R) = (1 - f)\ \frac{\sum_{i=1}^{n-1}(d_i - d_{i+1})^2}{2n\ (n - 1)\overline{x}^2}$$

The estimate of the true population Y is found by multiplying the density estimate by the total area under consideration, that is:

$\hat{Y} = \hat{R} \cdot A$ and the estimate of the variance of Y is obtained by multiplying the variance estimator of R by the square of the survey area.

$$\hat{V}(Y) = [A^2 \cdot \hat{V}(R)].$$

Confidence intervals (95%) for the true density and the true population total are given by:

$$R: \quad \hat{R} \pm t_{\frac{\alpha}{2}, n-1} \sqrt{\hat{V}(R)}$$

$$Y: \quad \hat{Y} \pm t_{\frac{\alpha}{2}, n-1} \sqrt{\hat{V}(Y)}$$

The estimates were calculated on the basis of a maximum strip transect width of 1.714 km wide (0.857 km either side of the helicopter). Thus, all observations with a measured angle of depression of 6° or more were used in calculating the estimates. Observations with measured angles below the horizon of 5° or less were considered to be "off transect" and were not included in the above analysis.

2. Nonsystematic Aerial Searches

Aerial searches were flown in June 1988 with a Bell-206B helicopter on high skid gear. Aerial searches were flown in July 1988 with either a Twin Otter aircraft (on tundra wheels) or a Bell-206B on floats. All search flights were flown at about 90 m agl and air speeds of about 160 km $\cdot$ h^{-1}. A four-person observer crew was used as outlined for surveys. When the Twin Otter was used, one observer rode in the copilot's seat and the other two observers sat in the first seat behind the cockpit wall on each side of the aircraft.

3. Definitions Of Terms Or Style

3.1. On transect

In this report all animals seen "on transect" are those animals that were seen within a strip width of 857 m on either side of the helicopter. The location of animals within that strip width was determined by the observer by reading an angle of depression of 6° or more with the hand held clinometer. The 857-m-wide strip from each side of the helicopter was combined for a maximum feasible strip width of 1.714 km.

3.2. On survey

In this report animals seen "on survey" are all of the animals seen by the observers while the helicopter was flying

along the line transects. This condition excludes all animals seen only while the helicopter was flying to or from the line transects (that is, flying to or from fuel caches or the base camp).

3.3. Off survey

In this report all animals seen "off survey" are those animals seen only while the helicopter was flying to or from fuel caches or the base camp (excludes all animals seen on survey).

3.4. Sex/age classification

Recognition of muskox sex/age classes was restricted to bulls, calves, and others. No special effort was made to separate cows from juveniles and no attempt was made to identify yearlings.

Peary caribou were recognized and classified by sex/age class as follows.

3.4.1. "Bulls" (mature males, assumed 4+ yr-old) are recognized by the relatively large size and advanced development of their new antler growth, which is exaggerated by the presence of velvet on the antlers. Diagnostic characteristics were the large diameter of the main beams; the long, posteriorly curved main beams; and the presence of well-developed, anteriorly directed brow or bez tines. Secondary characteristics include large body size, relatively large head size; and new pelage, especially on the lateral parts of the body and on the face. When the caribou under consideration exhibits male-like antler growth, the following exercise is used to distinguish bulls from juvenile males. The observer distinguished mature males from juvenile males by mentally evaluating the length of the new antler growth present in relation to the length of the animal's head (from crown of skull to tip of nose). When the antler growth is longer than the head - the animal is classified as a bull; and if shorter than the head - a juvenile male.

3.4.2. "Cows" (mature females, assumed 3+ yr-old) are recognized by the retention of hard antlers from the previous year or the absence of antlers and any new growth of antlers. In some few cases, minor new growth on the simple main beams has begun (such new growth most likely occurs among individuals just coming of age or possibly some few older cows that maintained better physical condition because they did not have the added burden of carrying a fetus and nursing a calf in the current year). Cows, especially those that calved in the current year, still retain much of their previous winter's pelage and have a faded, lifeless, often patchy appearance about them (relative to other sex/age classes in July). The general drab appearance of a successful

maternal cow often remains clearly recognizable into August of the year.

3.4.3. "Juvenile males" (males, assumed 1-3 yr-old) are recognized by their new pelage and their advanced, well-developed, but relatively small (when compared to bulls) new antler growth. Also, their relatively small body size (especially that of yearlings), when compared to adults, aids in their separation from bulls and cows.

3.4.4. "Juvenile females" (females, assumed 1-3 yr-old) are recognized by their new pelage, new antler growth, and relatively small body size (particularly yearlings). They are separated from juvenile males by the new antler growth appearing shorter than the ears and being restricted to small spike-like main beams or at the most, small main beams with simple branching. Antler growth characteristics together with the relatively small body size and new pelage separates them from cows or bulls.

3.5. Caribou group or muskox herd

A "caribou group" or "muskox herd" is composed of two or more individuals of the same species that were seen in close association (no fixed minimum or maximum distance of separation but usually much closer than 100 m) and apparently spatially isolated from other individuals of the same species at the time of observation. Two or more individuals (of the same species) are considered as one group even if they were more than 100 m apart but moved together when disturbed by the survey aircraft.

3.6. Bull-only caribou group or bull-only muskox herd

A "bull-only caribou group" is composed of mature males only (bulls, assumed 4+ yr old, relatively large antler size). In July of the year both bulls and immature males (at least 2-yr-old and possibly 1-yr olds) are readily recognizable by their relatively advanced antler development from other sex/age classes of Peary caribou. A "bull-only muskox herd" is composed of only bulls (assumed 4+ yr old that can be readily recognized by their large body size, and their relatively large horn size and well developed boss area of the horns.

3.7. Mixed sex/age caribou group or mixed sex/age muskox herd

A "mixed sex/age caribou group" or a "mixed sex/age muskox herd" may be mixed by sex or age or both and contains any possible combination of bulls, cows, juveniles, yearlings, or calves (when bulls could not be recognized, the presence of both sexes was not determined).

3.8. Values in parentheses

When values are given in parentheses (x + y) they always equal 1+ yr-old animals plus calves in this report: e.g., caribou (36 + 11) equals 36, 1+ yr-old caribou plus 11 caribou calves.

3.9. Estimates

All estimates presented herein are those obtained from use of the maximum feasible transect width of 1.714 km (857 m either side of the aircraft) at 6.4-km or 3.2-km intervals. The calculations for the estimates are based on the assumption that the helicopter was 90 m agl when each observation was made. This means that only those animals that were seen along the line transects for which readings to the nearest degree (on hand held clinometers) of the angle from the horizontal plane of the helicopter to the animals were 6° or greater were used to obtain the estimates. All animals sighted at 5° or less were considered "off transect" in the calculation of estimates. Two sets of estimates were produced. The first set includes all animals regardless of age and is used for comparisons with previous studies, as all previous researchers included calves in their estimates, except Miller (1987b). The second set excludes calves and considers only 1+ yr-old animals. The second set of estimates has been included because I believe that estimates for management purposes should be based on only those animals 1+ yr-old, as calves frequently suffer high losses throughout the first year of life. Thus, high calf mortality can distort estimates of numbers that include calves by as much as 20 to 25%. Therefore, I suggest that for management decisions, only 1+ yr-old animals be considered, when determining allowable rates of harvests and considering the status of each population.

The reader may note that slight inconsistencies sometimes occur between the summations of estimates by each survey stratum when compared with their counterparts that are obtained from a single estimate of several or all survey strata. The magnitude of these discrepancies is insignificant and they are pointed out only to assure the reader that the errors are the results of the method of machine calculation and not errors of transcription.

3.10. Sites

In this report a solitary animal is not considered as a group. Therefore, the term "site" is used to distinguish any observation regardless of whether it involved a solitary animal or a group of two or more animals. Site is essentially synonymous with observation.

3.11. Western satellite islands

The five relatively small satellite islands of Alexander, Marc, Massey, Vanier and Cameron that lay off the western coast of Bathurst Island will be collectively referred to in this report as the "five western satellite islands".

3.12. Northern satellite island

The relatively small satellite island of Helena that lies off the north coast of Bathurst Island is referred to as the "one northern satellite island".

3.13. Eastern satellite islands

The relatively small island of Little Cornwallis, interjacent to Bathurst and Cornwallis islands, and the moderately large but unproductive island of Cornwallis to the east of Bathurst Island are referred to as the "two eastern satellite islands" (in terms of possible movements or migrations of Peary caribou and muskoxen within the nine-island complex).

3.14. Measurements and units

The measurements taken and units used are as given in detail in Miller (1987a, 1987b, 1988).

RESULTS

1. Systematic Aerial Survey

Bathurst, Alexander, Marc, Massey, Vanier, Cameron, Helena, Little Cornwallis and Cornwallis islands were aerially surveyed between 11 and 21 July 1988 (Tables 1-2, App. 1-3). All islands were surveyed along systematically spaced north-south line transects: Bathurst, Helena, Little Cornwallis and Cornwallis at 6.4-km intervals; and Alexander, Marc, Massey, Vanier and Cameron at 3.2-km intervals (Tables 1-2, App. 1-3). Visibility and flying conditions were favourable, and only 3 days were lost to weather (16, 17 and 19 July).

1.1. Peary caribou

1.1.1. Peary caribou numbers seen and their distributions

I saw 636 (467 + 169) Peary caribou on eight of the nine islands surveyed (Table 3). No caribou were seen on Little Cornwallis Island during the aerial survey but two bulls were seen off survey on the northwest coast on 20 July during a return flight to Resolute Bay, Cornwallis Island. Most of the caribou

(62.3%) were seen on Bathurst Island: of those 396, 53.0% (145 + 65) were seen on St. II, 29.1% (85 + 30) on St. I and 17.9% (57 + 14) on St. III. The remaining 240 caribou (180 + 60) were seen on seven of the eight other islands surveyed in July 1988 (Table 3). No clear pattern for the within stratum distribution of caribou could be discerned nor could any meaningful within stratum areas of concentration be detected on any of the nine islands.

The 638 caribou seen (on or off survey) occurred at rates about as expected by chance alone on a proportional landmass basis, when frequency of occurrence of caribou on Bathurst Island is compared to the collective frequency of occurrence for the other eight islands surveyed (Bathurst Island 16 090 km^2, 396 caribou vs. eight other islands 10 806 km^2, 240 caribou: χ^2 = 1.53, df = 1; P >0.05). However, the distribution of those caribou was not in accordance with the relative size of each of the nine islands. Caribou occurred at greater than expected rates by chance alone on Alexander, Marc, Massey, Vanier and Helena; about as expected on Bathurst Island; and at less than expected rates on Cameron, Little Cornwallis and Cornwallis islands (χ^2 = 814.95, df = 8; P <0.005). Also, on a proportionate landmass basis, bulls (χ^2 = 9.89, df = 8; P <0.005) and nonbreeding females and junveniles or yearlings of either sex (χ^2 = 9.96, df = 8; P <0.005) were overrepresented on the eight islands surrounding Bathurst Island; while breeding cows (χ^2 = 0.05, df = 8; P >0.05) and calves (χ^2 = 1.63, df = 8; P >0.05) occurred about as expected by chance alone on both areas.

Observed frequencies of occurrence of Peary caribou among the three survey strata on Bathurst Island were greater on St. I and St. II than on St. III (χ^2 = 39.05, df = 2; P <0.005). Percentage distributions of nonbreeding females and juveniles or yearlings of either sex followed the same pattern (χ^2 = 9.39, df = 2; P <0.01); while breeding cows (χ^2 = 19.39, df = 2; P <0.005) and calves (χ^2 = 22.41, df = 2; P <0.005) were overrepresented only on St. II, occurred about as expected on St. I and were underrepresented on St. III; and bulls yielded no significant differences among survey strata (Table 4: χ^2 = 2.61, df = 2; P >0.05).

No pattern could be discerned for the distribution of caribou on each of the eight other islands (St. IV-XI). However, the relative occurrence of caribou among the eight islands varied significantly (χ^2 = 861.27, df = 7; P <0.005). Caribou were proportionately overrepresented on Alexander, Marc, Massey, Vanier and Helena islands; and proportionately underrepresented on Cameron, Little Cornwallis and Cornwallis islands. Sex/age classes of the caribou seen also varied markedly among islands, but could not be tested statistically because of the absence of various sex/age classes on some of the islands (too many zero

cells). Bulls and/or juvenile males were the only sex/age classes seen on Marc, Cameron and Little Cornwallis islands. Breeding females and calves occurred at high rates on Massey Island but no bulls or identifiable juvenile males were seen there. All sex/age classes of caribou were seen on Vanier, Helena and Cornwallis islands, at a moderate rate on Vanier but in too low numbers on Helena and Cornwallis to be evaluated.

1.1.2. Peary caribou estimates

I estimated that there were about 1103 ± 146 (S.E.) Peary caribou at a mean density of 4.101 ± 0.543 (S.E.) caribou · 100 km^{-2} on the nine-island survey area in July 1988 (Tables 4, 5). Most (74.4%) caribou occurred on Bathurst Island: 821 ± 138 (S.E.) caribou at 5.103 ± 0.858 (S.E.) caribou · 100 km^{-2} (Tables 4, 5). Contribution to the estimates for caribou on Bathurst Island was greatest on St. II, followed by St. I and least on St. III (Tables 4, 5). Collective estimates for all five western satellite islands equaled about 213 ± 37 (S.E.) at a mean density of 6.707 ± 1.165 (S.E.) caribou · 100 km^{-2} (Tables 4, 5). Collective estimates for Helena, Little Cornwallis and Cornwallis islands were only about 68 ± 28 (S.E.) caribou at 0.891 ± 0.037 (S.E.) caribou · 100 km^{-2} (Tables 4, 5).

When only 1+ yr-old caribou were considered, I obtained estimates of about 820 ± 105 (S.E.) caribou at 3.049 ± 0.390 (S.E.) caribou · 100 km^{-2} on the nine-island survey area (Tables 6, 7). Contributions to the overall estimates followed the same patterns as for all caribou with about 611 ± 99 (S.E.) caribou at 3.797 ± 0.615 (S.E.) caribou · 100 km^{-2} on Bathurst Island, 156 ± 26 (S.E.) caribou at 4.912 ± 0.819 (S.E.) caribou · 100 km^{-2} on the five western satellite islands, and 53 ± 23 (S.E.) caribou at 0.695 ± 0.301 (S.E.) caribou · 100 km^{-2} on the northern and eastern satellite islands (Tables 6, 7: Helena, Little Cornwallis and Cornwallis).

While the estimated mean densities for all caribou on four of the five western satellite islands exceeded the overall mean density for all caribou on Bathurst Island, the mean density for all caribou on St. II of Bathurst Island exceeded those for all but two of the five western satellite islands (Table 5). However, 31% of the contribution to the mean density for all caribou on St. II of Bathurst Island was made by calves. Thus, when only 1+ yr-old caribou are considered, mean densities for four of the five western satellite islands exceed all of those for all three survey strata on Bathurst Island (Table 7).

1.1.3. Peary caribou reproduction and early calf survival

Calves represented 26.5% of all 638 caribou seen on and off survey and 85.8% of the identified breeding cows had calves at

heel (Tables 3, 8). The segregation of those 638 caribou suggests that the precalving sex/age composition of the population within the survey area approached 18.3% bulls, 42.0% breeding cows, and 39.7% nonbreeding females and juveniles or yearlings of either sex. Bulls were well represented at 43.7 bulls per 100 breeding cows. I judged that at least 49 of the 186 caribou classified as nonbreeding females and juveniles or yearlings were actually nonbreeding cows that failed to conceive in 1987 or females just coming of age in summer 1988. If the foregoing assumption is correct, females (1+ yr-old) actually represented more than 52% (246 = 197 breeding cows + 49 nonbreeding females) and possibly as much as about 63% (296 = 197 breeding cows + 49 nonbreeding females + 50 juvenile females) of the precalving population. This condition suggests that somewhere between 67 and 80% of the females present in autumn 1987 conceived and produced calves in June 1988 and that between 57 and 69% of them still had calves at heel in July 1988.

Representation of caribou calves varied markedly among survey strata (Table 8): the greatest rate occurred on Massey Island but the lowest rate occurred on the adjacent island of Alexander. Collectively, the rate of occurrence of calves on Bathurst Island (St. I-III) exceeded all other islands except Massey Island. However, on Bathurst Island relative rates of occurrence for caribou calves (Table 8) did not follow exactly the relative rates for calves at heel: St. I, 100 calves:100 breeding cows; St. II, 92.8 calves; and St. III, 73.7.

Fifty-eight (79.5%) of the mixed sex/age groups with calves present ranged in size from 2-9 individuals and held 65.7% (111) of all calves; 19.2% (14) of the groups ranged from 10 to 18 individuals each and contained 30.8% (50) of the calves; and one (1.4%) group of 20 individuals had 6 (3.6%) of the calves (Table 9). The greatest number of caribou calves in any one group occurred in the largest group - 14 1+ yr-olds, and 6 calves.

1.1.4. Peary caribou group formations

The 636 Peary caribou seen on survey were on 123 sites: 98% in 110 groups of two or more individuals; and the remaining 2% as 13 solitary individuals (Tables 10, 11). All groups averaged 5.7 + 3.81 (S.D.) and ranged from 2-20 individuals in each group (5.0-6.4, 95% C.I.). Group types included 19.1% (21) bull-only groups and 80.9% (89) mixed sex/age groups (Table 11). Caribou calves were present in 82% of the mixed sex/age groups seen (Table 11). Grouping dynamics for caribou on Bathurst Island (St. I-III) compared to those for all caribou on the five western satellite islands (St. IV-VIII) were similar (Table 11).

1.2. Muskoxen

1.2.1. Muskox numbers and their distributions

I saw 398 muskoxen (346 + 52) on five of the nine islands surveyed (Table 12). No muskoxen were seen on or off survey on the islands of Marc, Massey, Helena and Little Cornwallis. The frequencies of occurrence of muskoxen on the five islands varied significantly: muskoxen were proportionately overrepresented on a relative landmass basis only on Bathurst Island, and underrepresented on Cornwallis, Alexander, Vanier and Cameron islands ($\chi^2 = 59.67$, df = 4; $P < 0.005$).

Most (80.4%) of the muskoxen were seen on Bathurst Island: of those 320, 61.3% (169 + 27) were seen on St. III; 28.1% (78 + 12) on St. I; and 10.6% (34 + 0) on St. II. Observed frequencies of occurrence of muskoxen among the three survey strata on Bathurst Island relative to the landmass of each stratum were greater on St. III and St. I than on St. II ($\chi^2 = 148.54$, df = 2; $P < 0.005$). Percentage distributions of all of the sex/age classes followed the same distributional pattern ($\chi^2 = 151.26$, df = 4; $P < 0.005$).

The remaining 78 muskoxen (65 + 13) were seen on four of the other eight islands surveyed in July 1988 (Table 12). Numbers were too low to discern any clear patterns for the within stratum distribution of muskoxen on Alexander, Vanier or Cameron islands. Only bulls were seen on Ile Vanier and Cameron Island while one herd of three muskoxen on Alexander Island contained two muskoxen identified as cows. On Cornwallis Island 77.6% of the 67 muskoxen seen were found in the drainages of the Eleanor River and its tributaries. The remaining 15 muskoxen were scattered and on patches of better vegetation in large river drainages on the southwest of the island.

1.2.2. Muskox estimates

I estimated that there were about 591 + 113 (S.E.) muskoxen at a mean density of 2.197 $\pm$ 0.420 (S.E.) muskoxen · 100 km^{-2} on the nine-island survey area in July 1988 (Tables 13, 14). Most (85.1%) muskoxen occurred on Bathurst Island: 503 + 108 (S.E.) muskoxen at 3.126 $\pm$ 0.671 (S.E.) muskoxen · 100 km^{-2} (Tables 13, 14). Contribution to estimates for muskoxen on Bathurst Island was greatest on St. III, followed by St. I and least on St. II (Tables 13, 14). Collective estimates for all five western satellite islands equalled only about 18 + 6 (S.E.) muskoxen at 0.567 $\pm$ 0.189 (S.E.) muskoxen · 100 km^{-2} (Tables 13, 14). The estimates for Cornwallis Island were only about 70 $\pm$ 34 (S.E.) muskoxen at 0.994 $\pm$ 0.487 (S.E.) muskoxen · 100 km^{-2} (Tables 13, 14).

When only 1+ yr-old muskoxen were considered, I obtained estimates of about 496 ± 88 (S.E.) muskoxen at a mean density of 1.844 ± 0.327 (S.E.) muskoxen · 100 km^{-2} on the nine-island survey area (Tables 15, 16). Contributions to the overall estimates followed the same patterns as for all muskoxen with about 423 ± 83 (S.E.) muskoxen at 2.629 ± 0.516 (S.E.) muskoxen · 100 km^{-2} on Bathurst Island; 18 ± 6 (S.E.) muskoxen at 0.567 ± 0.189 (S.E.) muskoxen · 100 km^{-2} on the five western satellite islands; and 55 ± 28 (S.E.) muskoxen at 0.785 ± 0.400 (S.E.) muskoxen · 100 km^{-2} on Cornwallis Island (Tables 15, 16).

1.2.3. Muskox reproduction and early calf survival

Muskox calves were seen on only two of the nine islands surveyed in July 1988 and they represented 13.1% of all muskoxen seen (Tables 12, 17). Proportional representation of muskox calves on Bathurst Island (12.2%) was, for unknown reason(s), only abaout 63% as great as that on Cornwallis Island (Table 17).

Fourteen (51.9%) of the herds with calves present ranged in size from 2-9 individuals and held 40.4% (21) of all calves; 44.4% (12) of the herds ranged from 10-19 individuals each and contained 48.1% (25) of the calves; and one (3.7%) herd of 25 individuals had 6 (11.5%) of the calves (Table 18).

1.2.4. Muskox herd formations

The 398 muskoxen were seen on 91 sites: 91% in 55 herds of two or more individuals; and the remaining 9.0% as 36 solitary bulls (Tables 19, 20). All muskox herds averaged 6.6 ± 4.67 (S.D.) and ranged from 2-25 individuals each (5.3-7.8, 95% C.I.). Herd types included 36.4% (20) bull-only herds; and 63.6% (35) mixed sex/age herds (Table 20). Muskox calves were present in 77.1% (27) of the mixed sex/age herds (Table 20). The greatest number of muskox calves in any one herd occurred in the largest herd: 19 1+ yr-olds, and 6 calves.

2. Nonsystematic Aerial Searches

2.1. June 1988

I obtained sex/age classifications on 187 Peary caribou between 8 and 18 June (App. 4, 5). Differences in the locations of caribou classified on 15 June from those classified on 18 June allow me to use a sample of 170 of those caribou as different individuals (Table 21). Bulls contributed 17.6% to the sample; breeding cows, 29.4%; newborn calves, 10.6% nonbreeding females and juveniles of either sex, 34.7%; and yearlings of either sex, 7.7% (Table 21). The sample suggests that the precalving population approached 19.7% bulls, 32.9% breeding cows, 38.8%

nonbreeding females and juveniles of either sex and 8.6% yearlings of either sex (Table 21).

The first newborn calf was seen on 8 June: it was obviously only hours old by its ungainly locomotion. No other caribou were seen within several kilometers of the cow-calf pair. However, only 14 caribou were seen on that date. Calves represented 10.6% of the sample of 170 caribou by 18 June 1988 and only 36% of the breeding cows had calves at heel (Table 21).

The only direct evidence for inter-island movements or migrations of Peary caribou was obtained on 8 June 1988. While the helicopter was crossing the middle of Baker Island (7 km^2), two caribou were spotted on the sea ice about 2 km off shore and approaching the island from the north-northwest. At closer range it could be seen that both caribou on the sea ice were bulls, and that they were following a fresh caribou trail in the snow on the sea ice that led onto the northwest corner of Baker Island. The trail led us to two more bulls that were foraging on the northwest corner of the island. No other caribou or their sign was found during our aerial search of the entire island. We then flew along the back trail toward Bathurst Island, but a strong ground drift of blowing snow obliterated the trail by the time we were within 2-3 km of the southeast corner of Bathurst Island.

Indirect evidence for inter-island movements of Peary caribou also comes from changing numbers of caribou on Baker Island (different sex/age classes present on different dates). Four bulls were seen on Baker Island on 8 June; only two bulls and one juvenile male were seen on 15 and 18 June and no caribou were seen there on 10 July 1988.

2.2. July 1988

Fourteen small islands south, southeast and east of Bathurst Island were aerially searched in their entireties between 10 and 21 July 1988. The islands of Browne, Griffith, Garrett, Hamilton, Lowther, Somerville and Young in Barrow Strait and Baker and Moore in Intrepid Passage were searched by Twin Otter aircraft on 10 July 1988. Only eight caribou were seen and all of them were on Lowther Island: 1 bull, 3 breeding cows, 2 calves and 2 juveniles or yearlings of undetermined sex. The islands of Crozier, Kalivik, Milne, Neal and Truro in McDougall Sound between Cornwallis or Little Cornwallis islands and Bathurst Island were searched by Bell-206B helicopter on several positioning flights between 15 and 21 July 1988. No caribou were seen on any of those five islands.

DISCUSSION

1. Peary Caribou

In this report I make the assumption that many, if not most, of the Peary caribou on these nine south-central Queen Elizabeth Islands belong to an inter-island population that uses Bathurst Island and one or more of, at least, these eight other islands surrounding Bathurst during the annual cycle of movements and migrations to seasonal ranges. The number of resident caribou on an island within this complex in any one year may vary markedly as may the numbers moving among islands due to traditions and the severity of then prevailing environmental conditions.

1.1. Peary caribou estimates

Although the 1988 mean density for Peary caribou on Bathurst Island is about 1.7 times greater than that for 1985 (Miller 1987a) and 3.6 times greater than the 1974 estimate (Miller et al. 1977a), it is still 3.3 times less than the mean density estimated in summer 1961 (Tener 1961, 1963) (Table 22). The collective mean density of caribou on the five western satellite islands in 1988 was only 93% of that in 1985 (Miller 1987a) but 8.5 times greater than that in 1974 (Miller et al. 1977a). However, the 1988 estimate is still about 4.0 times less than the mean density estimated in summer 1961 (Table 22). The same pattern of relatively high mean densities of caribou on the five western satellite islands compared to those on Bathurst Island also occurred in summer 1985 (Miller 1987a) and in summer 1961 (Tener 1961, 1963). Although Massey Island had the highest mean densities in 1988 and 1985 (Miller 1987a) among the five western satellite islands, it had the lowest mean density in summer 1961 (Tener 1961, 1963: Ile Marc was not surveyed in 1961). The extrapolated total number of caribou on the five western satellite islands in summer 1974 was negligible (N = 25) and the associated collective mean density (0.787 · 100 km^{-2}) was lower than that for caribou on Bathurst Island (Miller et al. 1977a). The number of caribou had also declined markedly on Bathurst Island (Miller et al. 1977a: 68%) but the mean density was reduced less on Bathurst Island (1.436 caribou · 100 km^{-2}) than on the five western satellite islands (Table 22).

In July 1988 I estimated the largest number of Peary caribou on Bathurst Island and within the entire nine-island complex since summer 1961 (Table 22).

The number of Peary caribou within the nine-island Bathurst Island complex during 27 years apparently has from 1961 to 1988 (1) declined by about 76% during the first 12 years; (2) then, markedly decreased by about 68% in the winter of 1973-74 and

further declined at least to as little as 7% of their 1961 level; (3) subsequently, the caribou took about a decade to apparently increase to about 20% of their 1961 level in summer 1985; (4) and finally, it now appears that in summer 1988 they have regained about 31% of their 1961 level within the nine-island complex.

1.2. Peary caribou numbers seen and their distributions

Most Peary caribou on Bathurst Island occurred north (St. I and St. II) rather than south (St. III) of Bracebridge-Goodsir inlets which is consistent with all previous summer observations between 1961 and 1988 (Table 23). The numbers and distributions of caribou seen among the three survey strata on Bathurst Island in July 1988 (Fig. 1) are proportionally similar to those reported in summers 1961 by Tener (1961, 1963), 1974 by Miller et al. (1977a), 1974 and 1975 by Fischer and Duncan (1976) and 1981 by Ferguson (1987). The observed relative strength of numbers and their distribution differed in July 1985 (Miller 1987a) when St. I rather than St. II held the greatest proportion of caribou.

Reasons for variation in the relative importance of summer range on northwestern vs. northeastern Bathurst Island remain unknown. Perhaps, both the northwest and northeast sides of the island are used in most all summers and the short time frame of the aerial survey only catches part of the overall summertime distribution of caribou on Bathurst Island. Also, possibly, the east-west summertime distributions of caribou on Bathurst Island are influenced by the snow and ice conditions during the previous winter and the wintertime redistribution persists into the open water period and thus into or throughout the following summer. Whatever the reason(s), much of northern Bathurst appears satisfactory for summering caribou, based on previously observed summertime distributions. Thus, access to those ranges will become critical when the density of caribou increases markedly.

1.3. Peary caribou reproduction and early calf survival

Initial production and early survival of caribou were high and similar in 1988 and 1985 (Table 24). The exceptionally high rate reported for calves in 1975 (Table 24: Fischer and Duncan 1976) likely reflects the segregation of a small sample that had distorted representation of some or all of the sex/age classes, most likely lacking the bull component of the population. Why Gauthier (1975) failed to see any caribou calves while carrying out ground observations of Peary caribou on Bathurst Island from 13 June to 27 August 1974 and Miller et al. (1977a) failed to see any calves during the August 1974 aerial survey, yet Fischer and Duncan (1976) saw five calves in August

1974 remains unanswered. Mortality during the first year of life appears to remain severe; regardless of the initial high production and early survival of calves. Therefore, it cannot be assumed that a significant increase in the number of caribou will necessarily follow in the near future.

1.4. Peary caribou group formations

The average group size (excluding singles) for caribou in July 1988 (5.7) and July 1985 (5.4) were essentially the same. Mean group sizes in both 1988 and 1985 were slightly larger than the June-July 1961 value of 4.7 (Tener 1963) but lower than the August 1974 value of 6.4 (Miller et al. 1977a). The higher mean group size in August 1974 most likely was a reflection of the severe winter die-off during 1973-74 (Miller et al. 1977a), resulting in fewer but larger summertime groupings in 1974.

2. Muskoxen

In this report I assume that (1) Bathurst Island is the only important area for muskoxen within this nine-island complex; but (2) at least some of the other eight islands, especially Cornwallis and Little Cornwallis islands, serve as relief areas for muskoxen during periods of environmental stress. To date there is no evidence for muskoxen making annual inter-island seasonal migrations. There is, however, evidence for muskoxen making inter-island movements when exposed to widespread forage unavailability due to unfavourable snow or ice conditons on their better ranges (e.g., Miller et al. 1977a, Miller 1987b).

2.1. Muskox estimates

The overall mean density estimate for muskoxen in 1988 is only about 95% of the 1985 estimate of muskoxen on Bathurst and the five western satellite islands (Table 25). The mean density of muskoxen on Bathurst Island in July 1988 is even more similar (97%) to that estimated in July 1985 (Table 25). Both estimates are about 3.0 times greater than the lowest recorded estimate in summer 1974 but still 2.2 times less than the 1961 summer estimate of 7.060 muskoxen · 100 km^{-2} (Table 25).

In 1988 mean density of muskoxen on Alexander Island was only 20.7% of the 1985 estimate. This radical change probably does not represent a serious decline in the number of muskoxen on Alexander but reflects the chance event of a relatively high number of muskoxen (clumping effect) being on transect in 1985 compared to 1988. The collective mean density of muskoxen on all five western satellite islands in 1988 is only slightly lower than in 1985 (Table 25), which suggests possible redistribution of muskoxen among those five islands. The five western satellite islands never have supported many muskoxen, based on data from

1961 to 1988 (Table 25). After the catastrophic winter of 1973-74 no muskoxen were seen on any of the five western satellite islands (Table 25).

The mean density of muskoxen on Cornwallis Island was low in 1988 and always has been low since 1961 (Table 25).

2.2. Muskox numbers seen and their distributions

That most muskoxen prefer southern Bathurst Island becomes obvious from the data in Table 26. However, the southern coastal areas of northwestern Bathurst (St. I) are also often used heavily by muskoxen in summer (Tables 25, 26). The lack of muskoxen on northeastern Bathurst (St. II) north of the Polar Bear Pass area reflects the relative lack of well vegetated lowlands on that part of the island. The same areas important to muskoxen in summertime are probably also important to them throughout the year, based on limited wintertime information (Gray 1973), Miller et al. 1977a) and the distribution of well vegetated wet meadows on the island (Edlund 1983).

2.3. Muskox reproduction and early calf survival

Representation of muskox calves during the first summer of life appears to have been only low to moderate in all years that it was measured except in 1985 (Table 27). Whether or not those values (Table 27) reflect only low rates of early calf survival or also initially poor calf production is unknown. Gray (1973) saw no calves, yearlings or 2-yr olds from summer 1968 to 1971 during ground observations of muskoxen in the Polar Bear Pass area. Yearlings as well as calves are apparently subjected to high winter losses in some years. Therefore, an increase in the number of muskoxen cannot be predicted with confidence even when early survival of calves is high.

2.4. Muskox herd formations

The average herd size for muskoxen in July 1988 (6.6) was only about 69% as great as that in 1985 (Miller 1987a: 9.6). Mean sizes of muskox herds were smaller, being 5.6 and 4.0 in June-July 1961 (Tener 1963) and August 1974 (Miller et al. 1977a), respectively. The low August 1974 value undoubtedly reflects the severe winter of 1973-74, and the effects of high mortality were strongly evidence in the summer groupings by size and composition (Miller et al. 1977a). The relatively high mean values and larger ranges of herd sizes in 1985 and 1988 possibly reflect more favourable conditions for muskox survival in recent years (prior to spring 1988). The drop in mean herd size from 1985 to 1988 results mainly from the relatively low representation of muskox calves in 1988.

3. The Polar Bear Pass Area

The major valley on central Bathurst Island that runs east to west from Goodsir Inlet to Bracebridge Inlet is known as "Polar Bear Pass". The area is of special interest because of the long-term biological studies conducted there at Canada's National Museum of Science, High Arctic Research Station, and because the area has been accepted as a National Wildlife Area under the direction of Environment Canada. Therefore, I have compiled separately the total numbers of caribou and muskoxen seen on the area (Tables 28, 29). I include 10 km to either side of the line that joins the two inlets and forms the southern boundary of St. II and the northern boundary of St. III to encompass all of the likely summer ranges for both Peary caribou and muskoxen in the area.

There is no indication from aerial survey results between 1961 and 1988 (Table 28) that Polar Bear Pass holds any special summertime attraction for Peary caribou, with exception of the August 1974 observations (Miller et al. 1977a). The relatively high proportion of caribou seen in Polar Bear Pass during aerial survey in August 1974 is supported by ground observations: Gauthier (1975) saw only four solitary caribou between 18 and 24 June; 26 caribou in 13 groups, 7 July to 3 August; and 75 caribou in 12 groups, 13-27 August 1974. Why Fischer and Duncan (1976) saw no caribou in Polar Bear Pass between 18 and 25 August 1974 remains unknown. That Ferguson (1987) saw no caribou in Polar Bear Pass in August 1981, seemingly, argues for the August 1974 observations being of an isolated event. However, Ferguson (1987) did not encompass enough high ground in his St. 4 (Polar Bear Pass) to include much of the likely caribou summer range in the area. The high rate of caribou in Polar Bear Pass during August 1974 may have been a chance event or possibly a resultant distribution caused by or influenced by the catastrophic winter of 1973-74. Most evidence to date indicates that summer range in Polar Bear Pass is not important to Peary caribou at least over extended periods of time. However, unhindered passage through the pass to the north in spring and south in late summer or autumn is beneficial to the well-being of Peary caribou on Bathurst Island, as it allows maximization of northern ranges in summer and southern ones in winter.

The results from aerial surveys between 1961 and 1988 (Table 29) suggests that the importance of summer range in Polar Bear Pass for muskoxen has varied markedly among years. Tener's (1961, 1963) observations indicate that under a high island-wide mean density considerable proportional use is made of Polar Bear Pass. However, subsequent observations (Table 29) indicate less proportional use under lower island-wide mean densities. The area of Polar Bear Pass (as defined herein) is about 7.5% (1200 km^2) of

the entire landmass of Bathurst Island. Therefore, summertime frequencies of occurrence of muskoxen in Polar Bear Pass were markedly high on a proportionate landmass basis in all years, except 1985 and 1988. In both 1985 and 1988, had the muskoxen seen along the north and south shores of Bracebridge Inlet been located to the east in Polar Bear Pass, they would have brought the relative occurrences of muskoxen in the pass to significant levels. Also, in 1981, Ferguson (1987) used an area of only 404 km^2 which was, as he also suggested, too narrow. Had he included the highlands in his St. 4, the Polar Bear Pass area would have held 44% of all of the muskoxen seen on Bathurst Island in 1981. Polar Bear Pass and the coastal area of Bracebridge Inlet provide important summer ranges for muskoxen on Bathurst Island; and both areas should be included together in any future evaluations. Observations by Gray (1973) and Miller et al. (1977a) indicate that Polar Bear Pass is also used at high rates by muskoxen at other seasons of the year.

4. Nonsystematic Aerial Searches

Nonsystematic aerial searches were hindered by unfavourable flying and viewing conditions during the first 3 weeks of June 1988, due to heavy aseasonal snowfalls on 2 and 7 June and subsequent persistent strong ground drifts of blowing snow, widespread fog and "whiteout" conditions throughout the entire search area. Blowing snow was a particular hindrance when searching for caribou trails on the snow covered sea ice. Aseasonally low daily maximum temperatures kept the snow cover on the sea ice from setting up tracks and the wintery powder snow obliterated trails within hours of them being put down.

The then prevailing weather in June 1988 prevented us from investigating inter-island movement or seasonal migrations of Peary caribou among the islands of Alexander, Marc, Massey, Vanier, Cameron and Bathurst. However, indirect evidence for such movements comes from observations made on the five western satellite islands in July 1988. The presence of only bulls and juvenile males on Cameron and Marc islands and the absence of bulls or juvenile males among a relatively high density of breeding cows, calves and nonbreeding females, juveniles or yearlings of either sex on Massey Island argues for inter-island movements or seasonal migrations at least sometime since the 1987 rut. Also, although caribou cows and calves were seen on Cameron and Marc islands in July 1985 no bulls were seen among a relatively high density of all other sex/age classes on Massey Island (Miller 1987a), suggesting that Massey Island is likely a calving area that draws pregnant cows from at least some of the other four western satellite islands and probably some from Bathurst Island at varying among-year rates.

The results obtained from the aerial searches in June 1988 did provide dates of first calving and the temporal progression of the calving period for Peary caribou on Bathurst Island which previously were unknown. When the 10.6% calves (36 calves/100 breeding cows) among all the different caribou seen by 18 June is compared to the 26.5% calves (85.8 calves/100 breeding cows) in July 1988, it suggests that less than 40% of the calving in 1988 had already occurred by 18 June. Thus, it appears that the peak of calving did not occur in 1988 until after the middle of the third week of June and that calving probably extended into the fourth week of June, even though the first calf was seen on 8 June. Further studies during June of the year will add to our knowledge of the calving period for Peary caribou.

That little information was obtained on probable inter-island movements of Peary caribou among the south-central Queen Elizabeth Islands reflects the unfavourable weather conditions that prevailed there during June 1988. With time, we will collect sufficient data to understand the late winter-spring inter-island movements and migrations of Peary caribou within this south-central complex of islands (cf. Miller et al. 1977b, 1982).

Just being there during May-June of the year provides the opportunity for gaining empirical knowledge through direct observations of Peary caribou and late winter-spring environmental conditions. These observations will assist us in our understanding of what Peary caribou have to cope with and how they do it. For examp.e, had I been on site in May 1988, I would have witnessed record high positive maximum daily temperatures from 16 to 19 May: 3.4°C ± 0.69°C (S.E.), range 2.2-4.8°C; with associated strong winds, mean 73.5 km · h^{-1} ± 9.64 km · h^{-1} (S.E.), range 57.4-90.7 km · h^{-1} (Atmospheric Environment Service weather station records at Resolute Bay, Cornwallis Island, NWT). Those "Chinook-like" conditions initiated an aseasonal melt of the snow cover about 4 weeks earlier than normal that totally altered the characteristics of the snow cover. Shallow snow cover melted completely and there was free-running water in the larger streams, deeper powder snow cover turned to slush and refroze with a sudden drop in temperatures in late May. Daily maximum temperatures were below the long-term average throughout the first 3 weeks of June and a record low daily maximum temperature was set at Resolute Bay on 16 June 1988. Snowfall was aseasonally high in June 1988 with two severe storms occurring on 2 and 7 June. The result was that all the altered snow cover still existing after late May 1988 was refrozen as slush in shallow snow cover and as a layer of solid ice (ca. 8-13 cm thick) in deep snow cover (more than 30 cm deep). These conditions led to widespread forage unavailability on the interior of Bathurst and other islands. I judged that a full 80-90% of Bathurst could not be used for foraging by caribou or muskoxen for at least a full month from late May to the 4th week

of June in 1988 (based on my cursory visual observations during helicopter overflights and landings). I believe that the caribou coped with the situation because they are usually forced onto poor coastal range at that time of the year and they are capable of making a living on those poorly vegetated but exposed areas. Also, normally their calves are apparently not born until mid to late June of the year. On the other hand, I believe that the relatively low early survival of muskox calves on Bathurst Island and possibly the apparent increase in the number of muskoxen on Cornwallis Island in July 1988 reflects the stresses of the unusually early icing in May 1988. Most, if not all, of the muskox calves were probably born just before, during or just after the May melt period; thus, their maternal cows would have been forced to nurse them throughout a long period of severe and widespread forage unavailability. Also, muskoxen tracks were observed at water's edge on the south coast of Cornwallis Island on 13 June 1988, indicating that the muskoxen had been foraging on a raised gravel beach. Such sites contain little forage and even less of the kind that muskoxen are seeking at that time of the year. The poor foraging conditions were evident by the fact that the muskoxen were all just making individual small feeding crater holes usually less than 1-m in size rather than foraging collectively in large feeding craters.

SUMMARY DISCUSSION

The Inuit of Resolute Bay should be complemented on the maintenance of their voluntary bans on hunting of Peary caribou on Bathurst and Cornwallis islands, initiated in 1975 and 1982, respectively. I think that, if the increase in caribou on Bathurst Island is real and it continues, it would be in the best interest of the Resolute people to persist with their ban on hunting there for at least a while longer (probably a minimum of 5 years) to possibly assure ample time for a significant recovery. However, if some Resolute Bay hunters strongly wish to hunt Peary caribou on Bathurst Island, a token harvest is acceptable on a purely biological basis. Such a harvest should be small (10 or less) and restricted to only male caribou. Female caribou and especially females of breeding age should not be intentionally killed, as it could and likely would be counterproductive to the population's continued growth.

High Arctic Peary caribou probably cannot be "stockpiled" over the long run as they are periodically or sporadically subjected to high "density independent" mortality caused by widespread unavailability of forage which is brought on by unfavourable snow and ice conditions (Parker et al. 1975; Miller et al. 1977a, 1982). However, upswing periods in the cyclic-like changes in numbers of High Arctic caribou apparently can be overall positive for 20 to 30 years or even as long as 50 years, as suggested by studies in Greenland (Vibe 1967). Thus,

substantial populations (as in 1961) could be built up, supporting limited annual sustained harvests. I think for the time being, until better data are obtained, that an arbitrary level of 1000 estimated 1+ yr-old caribou should be set as a threshhold inter-island herd size for initiating harvesting on the nine-island survey area. Even then, every effort should be made to promote continued harvesting of caribou and muskoxen on Price of Wales and Somerset islands with little or no utilization of animals on Bathurst Island until necessary.

As an agency charged with encouraging the wise use of the nation's renewable resources the Canadian Wildlife Service should attempt to create a position that balances the preservation and conservation of those resources with the consumptive use of the resource. We must not lose sight of the fact that proper conservation includes wise utilization of the resource, when "standing stocks" will sustain such use (or when habitats are seriously threatened).

A renewable resource such as Peary caribou complicates this issue of sustained utilization because of the likelihood of the caribou suffering high mortality at time intervals of various but unknown (unpredictable) lengths. We cannot yet predict the severity of the Peary caribou's environment over time with any high degree of accuracy. More knowledge must be gained on how and why Peary caribou used their environment as they do during all seasons of the year, especially during the late winter-spring "pinch-period" on into calving and early post-calving periods.

CONCLUSIONS

The July 1988 estimate suggests a 3.5-fold increase in the number of Peary caribou on Bathurst Island since summer 1974 and a 1.7-fold increase over July 1985 (Table 22). Similar changes appear to have occurred when Bathurst Island is considered together with the five western satellite islands: 4.3-fold from 1974 to 1988; and 1.5-fold from 1985 to 1988 (Table 22). The July 1988 estimate for all Peary caribou within the nine-island Bathurst island complex and the estimate for all Peary caribou on Bathurst Island only are the first estimates for which statisical support indicate real (significant) changes have occurred since 1974 (Table 22). However, it is the presence of newborn calves (ca. 26%) in July 1988 that actually causes the significant difference between the number of Peary caribou present on Bathurst Island in 1988 vs. 1974. When only the 1+ yr-old caribou are compared the difference is nonsignificant: 1988, 611 $\pm$ 99 (S.E.) vs. 1974, 231 $\pm$ 130 (S.E.). Unfortunately, the difference in the number of 1+ yr-old caribou within the nine-island Bathurst Island complex in 1988 vs. 1974 cannot be tested statistically, because a standard error exists only for the Bathurst Island estimate in

1974 (Miller et al. 1977a). The total estimated number of 1+ yr-old caribou within the nine-island complex in summer 1974 is about 323, based on existing data from Miller et al. (1977a) and Fischer and Duncan (1976). If the magnitude of the Bathurst Island standard error of the estimate of ± 56.3% pertains to the overall estimate of 323 (i.e., ± 182) caribou, the difference between 1988 and 1974 would be nonsignificant. If, however, the standard error associated with the 323 caribou was ± 45% or less, the difference between 1988 and 1974 would be significant.

Empirically, I tentatively conclude that a gradual increase in the number of Peary caribou on Bathurst Island as indicated by the apparent trend established by the 1981, 1985 and 1988 estimates is real (Table 22). The exact magnitude of the increase may be questionable, as the 95% C.I. ranges between 551 and 1091 caribou in 1988. However, the extrapolation of one caribou seen to about 1.7 caribou estimated is less than for any other previous aerial survey of caribou on Bathurst Island and strengthens the acceptance of the 1988 estimate as an accurate approximation of reality. The 1988 estimate of 1103 caribou within the nine-island complex and the estimate of 821 caribou on Bathurst Island are, however, still only about 30% as large as the 1961 estimates of 3565 and 2723 caribou on those respective areas.

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Table 1

Basic statistics for aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area		Date(s) surveyed	Total length of transects
Island	Stratum	July 1988	(km)
Bathurst	I	20, 21	649.283
	II	18, 20	1046.957
	III	15	862.410
Alexander	IV	14	155.180
Marc	V	14	17.462
Massey	VI	14	140.096
Vanier	VII	13	357.593
Cameron	VIII	13	344.090
Helena	IX	20	52.387
Little Cornwallis	X	12	65.486
Cornwallis	XI	11, 12	1115.221

Table 2

Basic statistics for obtaining estimates of Peary caribou and muskoxen from a systematic aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area Island	Stratum	Total transects possible	Number of transects surveyed	Area surveyed (km^2)
Bathurst[a]	I	74	20	1112.87
	II	66	18	1794.48
	III	62	17	1478.17
Alexander[b]	IV	22	12	265.98
Marc[b]	V	7	4	29.93
Massey[b]	VI	25	14	240.13
Vanier[b]	VII	33	17	612.91
Cameron[b]	VIII	25	14	589.77
Helena[a]	IX	22	6	89.79
Little Cornwallis[a]	X	22	6	112.24
Cornwallis[a]	XI	56	15	1911.49

[a]Coverage equals 1.714-km wide strip transects at 6.4-km intervals.
[b]Coverage equals 1.714-km wide strip transects at 3.2-km intervals.

Table 3

Peary caribou seen during aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area by island	Caribou seen			Total 1+ yr-old caribou	Total all caribou
	Bulls	Calves	Others[a]		
Bathurst	38	109	249	287	396
Alexander	8	3	17	25	28
Marc	7		2[b]	9	9
Massey		30	54	54	84
Vanier	13	19	45	58	77
Cameron	6		2[b]	8	8
Helena	3	2	3	6	8
Little Cornwallis	(2)[c]				
Cornwallis	9	6	11	20	26

[a]Includes all females 1+ yr-old and young males.
[b]Both caribou were juvenile males just about to come of age (borderline bulls).
[c]No caribou were seen on survey but two bulls were seen off survey.

Table 4

Estimates of numbers of all Peary caribou on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	63	231.0	5839.3	71.1-390.9
	II	124	459.5	9712.7	251.6-667.5
	III	36	130.5	3482.4	5.4-255.6
Alexander	IV	17	31.3	173.2	2.4- 60.3
Marc	V	2	3.7	4.4	0.0- 10.4
Massey	VI	46	84.3	461.6	37.9-130-7
Vanier	VII	46	84.8	687.3	29.2-140.4
Cameron	VIII	5	9.0	19.8	0.0- 18.6
Helena	IX	7	17.2	94.1	0.0- 42.1
Cornwallis	XI	14	51.31	698.6	0.0-107.0

[a]No caribou were seen on survey on Little Cornwallis Island.
[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 5

Estimates of mean densities of all Peary caribou on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area Island	Stratum	Number of animals seen on transects[a]	Mean density • 100 km^2 Estimate	Variance	95% C.I.[b]
Bathurst	I	63	5.661	3.506	1.742- 9.580
	II	124	6.910	2.196	3.783-10.037
	III	36	2.435	1.212	0.101- 4.770
Alexander	IV	17	6.391	7.215	0.480-12.303
Marc	V	2	6.682	13.969	0.000-18.575
Massey	VI	14	19.157	23.844	8.610-29.704
Vanier	VII	46	7.505	5.382	2.587-12.423
Cameron	VIII	5	0.848	0.176	0.000- 1.754
Helena	IX	7	7.796	19.446	0.000-19.133
Cornwallis	XI	14	0.732	0.143	0.000- 1.542

[a]No caribou were seen on survey on Little Cornwallis Island.
[b]When the low confidence limit is a negative value, it is reported as 0.000.

Table 6

Estimates of numbers of Peary caribou (1+ yr-old only) on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	50	183.3	3225.5	64.4-302.2
	II	86	318.7	4111.6	183.4-454.0
	III	30	108.8	2497.3	2.8-214.7
Alexander	IV	14	25.8	132.9	0.4- 51.2
Marc	V	2	3.7	4.4	0.0- 10.4
Massey	VI	30	55.0	216.3	23.2- 86.7
Vanier	VII	34	62.7	318.4	24.9-100.5
Cameron	VIII	5	9.0	19.8	0.0- 18.6
Helena	IX	5	12.3	36.9	0.0- 27.9
Cornwallis	XI	11	40.3	493.3	0.0- 87.9

[a]No caribou were seen on Little Cornwallis Island.
[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 7

Estimates of mean densities of Peary caribou (1+ yr-old only) on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area Island	Stratum	Number of animals seen on transects[a]	Mean density · 100 km^{-2} Estimate	Variance	95% C.I.[b]
Bathurst	I	50	4.493	1.938	1.579- 7.406
	II	86	4.792	0.930	2.758- 6.827
	III	30	2.030	0.869	0.053- 4.006
Alexander	IV	14	5.264	5.535	0.085-10.442
Marc	V	2	6.682	13.969	0.000-18.575
Massey	VI	30	12.494	11.174	5.273-19.714
Vanier	VII	34	5.547	2.494	2.199- 8.895
Cameron	VIII	5	0.848	0.176	0.000- 1.754
Helena	IX	5	5.568	7.614	0.000-12.663
Cornwallis	XI	11	0.575	0.101	0.000- 1.256

[a]No caribou were seen on Little Cornwallis Island.
[b]When the low confidence limit is a negative value, it is reported as 0.000.

Table 8

Statistics for Peary caribou calves obtained by aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Island[a] and survey stratum	Number of calves	Calves as % of total caribou seen on stratum	Number groups with calves present	Calves/group		
				Mean	± S.D.	Range
Bathurst - St. I	30	26.1	9	3.3	2.00	1-6
Bathurst - St. II	65	31.0	30	2.2	0.91	1-4
Bathurst - St. III	14	19.7	8	1.8	0.71	1-3
Alexander - St. IV	3	10.7	2	1.5	0.71	1-2
Massey - St. VI	30	35.7	11	2.7	1.49	1-6
Vanier - St. VII	19	24.7	8	2.4	1.69	1-5
Helena - St. IX	2	25.0	1	2.0	--	2-2
Cornwallis - St. XI	6	23.1	4	1.5	0.68	1-2

[a]No calves were seen on Marc (St. V), Cameron (St. VIII) and Little Cornwallis (St. X) islands.

Table 9

Group statistics for Peary caribou groups with calves present, based on 1+ yr-old individuals only and given by number of calves present in each group, obtained by aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Group statistics	Number of calves/group					
	1	2	3	4	5	6
N	21	29	10	8	2	3
mean	2.71	4.10	5.00	7.35	8.00	11.67
± S.D.	2.39	2.05	2.31	2.44	1.41	2.51
Range	1-10	2- 3	3-11	4-11	7- 9	9-14
95% C.I.	1.62-3.80	3.32-4.88	3.35-6.65	5.21-9.29	4.71-20.71	5.43-17.91

Table 10

Grouping statistics from aerial surveys of Peary caribou on nine south-central Queen Elizabeth Islands, NWT, July 1988

Island[a]	Number groups including singles	Number singles	Group size excluding singles	
			Mean	Range
Bathurst	73	9	6.0	2-18
Alexander	9	1	3.4	2- 6
Marc	2	0	4.5	2- 7
Massey	12	1	7.5	2-20
Vanier	14	1	5.8	2-14
Cameron	3	0	2.7	2- 3
Helena	3	1	3.5	2- 5
Cornwallis	7	0	3.7	2- 7

[a]No Peary caribou were seen on survey on Little Cornwallis Island.

Table 11

Group statistics for Peary caribou on nine south-central Queen Elizabeth Islands, NWT, July 1988, obtained by aerial survey

Group types by island and survey stratum	Group statistics				
	N	Mean	± S.D.	Range	95% C.I.
Bathurst - St. I					
Bull-only groups	2	2.5	0.71	2- 3	0.0[a]-8.9
Mixed sex/age groups	11	9.8	5.46	2-18	6.2-13.5
Mixed sex/age groups with calves					
calves included	9	10.9	5.40	2-18	6.7-15.0
calves excluded	9	7.6	3.84	1-12	4.6-10.5
Mixed sex/age groups without calves	2	5.0	2.83	3- 7	0.0-30.4
Bathurst - St. II					
Bull-only groups	3	2.3	0.58	2- 3	0.9- 3.8
Mixed sex/age groups	35	5.7	2.54	2-13	4.8- 6.5
Mixed sex/age groups with calves					
calves included	30	5.9	2.60	2-13	5.0- 6.9
calves excluded	30	3.8	1.94	1- 9	3.0- 4.5
Mixed sex/age groups without calves	5	4.2	1.64	2- 6	2.2- 6.2

cont.

Table 11 cont.

Group types by island and survey stratum	N	Mean	± S.D.	Range	Group statistics 95% C.I.
Bathurst - St. III					
Bull-only groups	4	2.2	0.50	2- 3	1.5- 3.0
Mixed sex/age groups	9	6.6	3.58	2-11	3.8- 9.3
Mixed sex/age groups with calves					
calves included	8	7.0	3.55	2-11	4.0-10.0
calves excluded	8	5.3	3.37	1-10	2.4- 8.1
Mixed sex/age groups without calves	1	3.0	--	3- 3	--
Alexander - St. IV					
Bull-only groups	2	3.0	1.41	2- 4	0.0-15.7
Mixed sex/age groups	6	3.5	1.52	2- 6	1.9- 5.1
Mixed sex/age groups with calves					
calves included	2	4.0	2.83	2- 6	0.0-29.4
calves excluded	2	2.5	2.12	1- 4	0.0-21.6
Mixed sex/age groups without calves	4	3.3	0.96	2- 4	1.7- 4.8
Marc - St. V					
Bull-only groups	1	2.0	--	2- 2	--
Mixed sex/age groups	1	7.0	--	7- 7	--
Mixed sex/age groups without calves	1	7.0	--	7- 7	--

cont.

Table 11 cont.

Group types by island and survey stratum	Group statistics				
	N	Mean	± S.D.	Range	95% C.I.
Massey - St. VI					
Bull-only groups					
Mixed sex/age groups	11	7.5	4.72	2-20	3.3-10.7
Mixed sex/age groups with calves					
calves included	11	7.5	4.72	2-20	4.4-10.7
calves excluded	11	4.8	3.43	1-14	2.5- 7.1
Vanier - St. VII					
Bull-only groups	4	2.8	0.96	2- 4	1.2- 4.3
Mixed sex/age groups	9	7.2	4.76	2-14	3.6-10.9
Mixed sex/age groups with calves					
calves included	8	7.1	5.08	2-14	2.9-11.4
calves excluded	8	4.8	3.50	1- 9	1.8- 7.7
Mixed sex/age groups without calves	1	8.0	--	8- 8	--
Cameron - St. VIII					
Bull-only groups	3	2.7	0.58	2- 3	1.2- 4.1
Mixed sex/age groups	2[a]	2.5	0.71	2- 3	0.0- 8.9
Mixed sex/age groups without calves	2[a]	2.5	0.71	2- 3	0.0- 8.9

cont.

Table 11 cont.

Group types by island and survey stratum	Group statistics N	Mean	± S.D.	Range	95% C.I.
Helena - St. IX					
Bull-only groups	1	2.0	--	2- 2	--
Mixed sex/age groups	1	5.0	--	5- 5	--
Mixed sex/age groups with calves					
calves included	1	5.0	--	5- 5	--
calves excluded	1	3.0	--	3- 3	--
Cornwallis - St. XI					
Bull-only groups	3	2.3	0.58	2- 3	0.9- 3.8
Mixed sex/age groups	4	4.8	1.71	3- 7	2.0- 7.5
Mixed sex/age groups with calves					
calves included	4	4.8	1.71	3- 7	2.0- 7.5
calves excluded	4	3.3	1.89	2- 6	0.2- 6.3
Bathurst - (St. I-III)					
Bull-only groups	9	2.3	0.50	2- 3	1.9- 2.7
Mixed sex/age groups	55	6.7	3.76	2-18	5.7- 7.6
Mixed sex/age groups with calves					
calves included	47	7.1	3.86	2-18	6.0- 8.2
calves excluded	47	4.7	2.98	1-12	3.9- 5.6

cont.

Table 11 cont.

Group types by island and survey stratum	Group statistics				
	N	Mean	± S.D.	Range	95% C.I.
Mixed sex/age groups without calves	8	4.3	1.75	2- 7	2.8- 5.7
Five western satellite Is. - (St. IV-VIII)					
Bull-only groups	8	2.8	0.89	2- 4	2.0- 3.5
Mixed sex/age groups	29	6.2	4.30	2-20	4.6- 7.9
Mixed sex/age groups with calves					
calves included	21	7.0	4.65	2-20	4.9- 9.2
calves excluded	21	4.6	3.30	1-14	3.1- 6.1
Mixed sex/age groups without calves	8	4.1	2.23	2- 8	2.3- 6.0
All islands - (St. I-XI)					
Bull-only groups	21	2.5	0.68	2- 4	2.2- 2.8
Mixed sex/age groups	89	6.4	3.85	2-20	5.6- 7.2
Mixed sex/age groups with calves					
calves included	73	6.9	4.00	2-20	6.0- 7.8
calves excluded	73	4.6	3.00	1-14	3.9- 5.3
Mixed sex/age groups without calves	16	4.2	1.94	2- 8	3.2- 5.2

[a]Actually composed of bulls and juvenile males only.

Table 12

Muskoxen seen during aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area by island[a]	Muskoxen seen			1+ yr-old muskoxen	all muskoxen
	Bulls	Calves	Others[b]		
Bathurst	123	39	158	281	320
Alexander	2		2	4	4
Vanier	3			3	3
Cameron	4			4	4
Cornwallis	24	13	30	54	67

[a]No muskoxen were seen on survey (or off survey) on Marc, Massey, Helena, or Little Cornwallis islands.

[b]Includes all females 1+ yr-old and young males (and most likely some few bulls that were missed in the segregations).

Table 13

Estimates of numbers of all muskoxen on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	58	212.6	6584.6	42.8-382.5
	II	3	11.1	51.7	0.0- 26.3
	III	77	279.2	4986.9	129.5-428.9
Alexander	IV	3	5.5	14.6	0.0- 13.9
Vanier	VII	3	5.5	8.2	0.0- 11.6
Cameron	VIII	4	7.2	12.1	0.0- 14.7
Cornwallis	XI	19	69.6	1163.4	0.0-142.7

[a]No muskoxen were seen on Marc (St. V), Massey (St. VI), Helena (St. IX) and Little Cornwallis (St. X) islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 14

Estimates of mean densities of all muskoxen on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area		Number of animals seen on transects[a]	Mean density • 100 km^{-2}		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	58	5.212	3.956	1.049- 9.374
	II	3	0.167	0.012	0.000- 0.395
	III	77	5.209	1.736	2.416- 8.002
Alexander	IV	3	1.128	0.608	0.000- 2.844
Vanier	VII	3	0.489	0.065	0.000- 1.028
Cameron	VIII	4	0.678	0.107	0.000- 1.386
Cornwallis	XI	19	0.994	0.237	0.000- 2.039

[a]No muskoxen were seen on Marc (St. V), Massey (St. VI), Helena (St. IX) and Little Cornwallis islands.

[b]When the low confidence limit is a negative value, it is reported as 0.000.

Table 15

Estimates of numbers of muskoxen (1+ yr-old only) on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	49	179.6	4231.5	43.5-315.8
	II	3	11.1	51.7	0.0- 26.3
	III	64	232.1	2655.3	122.8-341.3
Alexander	IV	3	5.5	14.6	0.0- 13.9
Vanier	VII	3	5.5	8.2	0.0- 11.6
Cameron	VIII	4	7.2	12.1	0.0- 14.7
Cornwallis	XI	15	54.9	776.5	0.0-114.7

[a]No muskoxen were seen on Marc (St. V), Massey (St. VI), Helena (St. IX) and Little Cornwallis (St. X) islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 16

Estimates of mean densities of muskoxen (1+ yr-old only) on nine south-central Queen Elizabeth Islands, NWT, July 1988

Survey area Island	Stratum	Number of animals seen on transects[a]	Mean density · 100 km^{-2} Estimate	Variance	95% C.I.[b]
Bathurst	I	49	4.403	2.542	1.066- 7.740
	II	3	0.167	0.012	0.000- 0.395
	III	64	4.330	0.924	2.292- 6.368
Alexander	IV	3	1.128	0.608	0.000- 2.844
Vanier	VII	3	0.489	0.065	0.000- 1.028
Cameron	VIII	4	0.678	0.107	0.000- 1.386
Cornwallis	XI	15	0.785	0.159	0.000- 1.639

[a]No muskoxen were seen within stript transect areas on Marc (St. V), Massey (St. VI), Helena (IX) and Little Cornwallis (St. X) islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 17

Statistics for muskox calves obtained by aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Island[a] and survey stratum	Number of calves	Calves as % of total muskoxen seen on stratum	Number groups with calves present	Calves/herd		
				Mean	± S.D.	Range
Bathurst - St. I	12	13.3	5	2.4	2.07	1-6
Bathurst - St. III	27	13.8	14	1.9	1.07	1-4
Cornwallis - St. XI	13	19.4	8	1.6	0.52	1-2

[a]No muskox calves were seen on St. II of Bathurst Island or on Alexander (St. IV), Marc (St. V), Massey (St. VI), Vanier (St. VII), Cameron (St. VIII), Helena (St. IX) and Little Cornwallis (St. X) islands.

Table 18

Herd statistics for muskox herds with calves present, based on 1+ yr-old individuals only and given by number of calves present in each herd, obtained by aerial survey of nine south-central Queen Elizabeth Islands, NWT, July 1988

Herd statistics	Number of calves/herd					
	1	2	3	4	5	6
N	12	9	4	1	--	1
mean	6.92	6.00	10.00	9.00	--	19.00
± S.D.	2.35	2.78	4.97	0.00	--	0.00
Range	4-10	2-10	3-14	9- 9	--	19-19
95% C.I.	5.43-	3.86-	2.10-	--	--	--
	8.41	8.14	17.90	--	--	--

Table 19

Grouping statistics from aerial surveys of muskoxen on nine south-central Queen Elizabeth Islands, NWT, July 1988

Island[a]	Number herds including singles	Number singles	Herd size excluding singles	
			Mean	Range
Bathurst	69	29	7.3	2-25
Alexander	2	1	3.0	3- 3
Vanier	2	1	2.0	2- 2
Cameron	2	0	2.0	2- 2
Cornwallis	16	5	5.6	2-12

[a]No muskoxen were seen on survey on Marc, Massey, Helena and Little Cornwallis islands.

Table 20

Herd statistics for muskoxen on nine south-central Queen Elizabeth Islands, NWT, July 1988, obtained by aerial survey

Herd types by island and survey stratum	N	Mean	± S.D.	Range	Herd statistics 95% C.I.
Bathurst - St. I					
Bull-only herds	2	2.5	0.71	2- 3	0.0- 8.9
Mixed sex/age herds	6	12.0	6.51	7-25	5.2-18.8
Mixed sex/age herds with calves					
calves included	5	13.0	6.75	9-25	4.6-21.4
calves excluded	5	10.6	4.78	8-19	4.7-16.5
Mixed sex/age herds without calves	1	7.0	--	7- 7	--
Bathurst - St. II					
Bull-only herds	2	2.0	--	2- 2	--
Mixed sex/age herds	3	7.7	1.53	6- 9	3.9-11.5
Mixed sex/age herds without calves	3	7.7	1.53	6- 9	3.9-11.5
Bathurst - St. III					
Bull-only herds	10	2.6	0.70	2- 4	2.1- 3.1
Mixed sex/age herds	17	9.5	3.76	5-17	7.5-11.4
Mixed sex/age herds with calves					

cont.

Table 20 cont.

Herd types by island and survey stratum	Herd statistics				
	N	Mean	± S.D.	Range	95% C.I.
calves included	14	9.8	3.97	5-17	7.5-12.1
calves excluded	14	7.9	3.46	3-14	5.9- 9.9
Mixed sex/age herds without calves	3	8.0	2.65	5-10	1.4-14.6
Alexander - St. IV					
Bull-only herds					
Mixed sex/age herds	1	3.0	--	3- 3	--
Mixed sex/age herds without calves	1	3.0	--	3- 3	--
Vanier - St. VII					
Bull-only herds	2	2.0	--	2- 2	--
Cameron - St. VIII					
Bull-only herds	2	2.0	--	2- 2	--
Cornwallis - St. XI					
Bull-only herds	3	2.3	0.58	2- 3	0.9- 3.8
Mixed sex/age herds	8	6.9	2.53	4-12	4.8- 9.0
Mixed sex/age herds with calves					

cont.

Table 20 cont.

Herd types by island and survey stratum	Herd statistics				
	N	Mean	± S.D.	Range	95% C.I.
calves included	8	6.9	2.53	4-12	4.8- 9.0
calves excluded	8	5.3	2.49	2-10	3.2- 7.3
Bathurst - (St. I-III)					
Bull-only herds	14	2.5	0.65	2- 4	2.1- 2.9
Mixed sex/age herds	26	9.8	4.42	5-25	8.1-11.6
Mixed sex/age herds with calves					
calves included	19	10.6	4.86	5-25	8.3-13.0
calves excluded	19	8.6	3.91	3-19	6.7-10.5
Mixed sex/age herds without calves	7	7.7	1.80	5-10	6.1- 9.4
Five western satellite Is. - (St. IV-VIII)					
Bull-only herds	3	2.0	--	2- 2	--
Mixed sex/age herds	1	3.0	--	3- 3	--
Mixed sex/age herds without calves	1	3.0	--	3- 3	--
All islands - (St. I-XI)					
Bull-only herds	20	2.4	0.60	2- 4	2.1- 2.7
Mixed sex/age herds	35	9.0	4.28	3-25	7.6-10.4
Mixed sex/age herds with calves					

cont.

Table 20 cont.

Herd types by island and survey stratum	N	Mean	± S.D.	Herd statistics Range	95% C.I.
calves included	27	9.5	4.59	4-25	7.7-11.3
calves excluded	27	7.6	3.83	2-19	6.1- 9.1
Mixed sex/age herds without calves	8	7.1	2.36	3-10	5.2- 9.1

Table 21

Sex/age classification of 170 Peary caribou, obtained by nonsystematic aerial searches, south-central Queen Elizabeth Islands, NWT, June 1988

Island	Sex/age class					
	Bulls	Cows[a]	Calves	Juveniles[b]	Yearlings	Total
Bathurst	27	40	13	44	13	137
NE[c]	6	24	9	15	6	60
SE	2	2	1	2		7
S	5	5		14	4	28
SW	14	1	1	2	1	19
NW		8	2	11	2	23
Baker	2			1		3
Alexander	1	3		9		13
Massey		5	5	2		12
Vanier		2		3		5
Totals	30	50	18	59	13	170

[a]Only those individuals identified as breeding cows.
[b]Includes nonbreeding females and juveniles of either sex.
[c]Coastal areas of Bathurst Island where caribou were seen during aerial searches.

Table 22

Peary caribou summer population estimates on a nine-island, south-central Queen Elizabeth Islands complex[a], NWT, 1961-1988

Year	Month	Population estimate[b]	Mean density[c] (• 100 km^{-2})	Source[d]
Nine-island complex (26 896 km^2)				
1988	Jul.	1103	4.101	This study
Bathurst Island plus five western satellite islands (19 266 km^2)				
1988	Jul.	1034	5.367	This study
1985	Jul.	724	3.758	Miller (1987a)
1975	Jun.	361	1.874	Fischer and Duncan (1976)
1974	Aug.	228	1.183	Fischer and Duncan (1976)
1974	Aug.	256	1.329	Miller et al. (1977a)
1961	Jun.-Jul.	3565	18.504	Tener (1961, 1963)
Bathurst Island (16 090 km^2)				
1988	Jul.	821	5.103	This study
1985	Jul.	495	3.076	Miller (1987a)
1981	Aug.	289	1.796	Ferguson (1987)
1975	Jun.	349	2.169	Fischer and Duncan (1976)
1974	Aug.	190	1.181	Fischer and Duncan (1976)
1974	Aug.	231	1.436	Miller et al. (1977a)
1961	Jun-Jul.	2723	16.924	Tener (1961, 1963)

cont.

Table 22 cont.

Year	Month	Population estimate[b]	Mean density[c] (· 100 km^{-2})	Source[d]
Five western satellite islands (3176 km^2)				
1988	Jul.	213	6.707	This study
1985	Jul.	232	7.300	Miller (1987a)
1975	Jun.	12	0.378	Fischer and Duncan (1976)
1974	Aug.	38	1.196	Fischer and Duncan (1976)
1974	Aug.	25	0.787	Miller et al. (1977a)
1961	Jun.-Jul.	842	26.511	Tener (1961, 1963)
One northern satellite island (220 km^2)				
1988	Jul.	17	7.727	This study
1985	Jul.	0	0.000	Miller (1987a)
1975	Jun.	8	3.636	Fischer and Duncan (1976)
1974	Aug.	3	1.364	Miller et al. (1977a)
Two eastern satellite islands (7410 km^2)				
1988	Jul.	51	0.688	This study
1975	Jun.	0	0.000	Fischer and Duncan (1976)
1974	Jul.	52	0.702	Fischer and Duncan (1976)
1961	Jun.	43	0.580	Tener (1961, 1963)

cont.

Table 22 cont.

Year	Month	Population estimate[b]	Mean density[c] (· 100 km^{-2})	Source[d]

[a]Based on the assumption that Bathurst Island serves as the major Peary caribou island within the nine-island, south-central Queen Elizabeth Islands complex; and Alexander, Marc, Massey, Vanier and Cameron islands are five major western satellite islands to Bathurst Island; and Helena Island is the one major northern satellite island to Bathurst Island; and Little Cornwallis and Cornwallis islands are two major eastern satellite islands to Bathurst Island.

[b]Population estimates have been recalculated from the data sources, when necessary to fit the groupings presented in this table.

[c]Mean densities for 1961 to 1981 were recalculated, using the landmass size presented in the heading of each of these groupings to be in agreement with calculated sizes of land bases used in 1985 and 1988.

[d]Based on recalculation of data from these sources, whenever necessary to put in agreement with groupings and landmass sizes used in this report.

Table 23

Summary of relative ranking by survey stratum of Peary caribou by relative importance of percentage of total caribou seen on island (on and off transect), by relative importance of proportion of total estimated number of caribou for the entire island and by relative importance of the mean density by survey stratum, Bathurst Island, NWT, summers 1961-1988

Year	Relative importance - rank[a]			Source
	Stratum I	Stratum II	Stratum III	
1988	2nd (2nd) 2nd	1st (1st) 1st	3rd (3rd) 3rd	This study
1985	2nd (1st) 1st	1st (2nd) 2nd	3rd (3rd) 3rd	Miller (1987a)
1981	2nd (2nd) 2nd	1st (1st) 1st	3rd (3rd) 3rd	Ferguson (1987)
1975	2nd --[b] --[b]	1st -- --	3rd -- --	Fischer and Duncan (1976)
1974	1st -- --	3rd -- --	2nd -- --	Fischer and Duncan (1976)
1974	2nd (2nd) 2nd	1st (1st) 1st	3rd (3rd) 3rd	Miller et al. (1977a)
1961	1st (2nd) 1st	2nd (1st) 2nd	3rd (3rd) 3rd	Tener (1961, 1963)

[a]First value equals ranking for the relative importance of the percentage of total caribou seen; second value (in parentheses) equals relative importance for the proportion of total number of caribou estimated; and the third value equals relative importance of the mean density among the three survey strata (where: 1st = most; 2nd = moderate; and 3rd = least).

[b]Data source does not allow breakdown at survey stratum level.

Table 24

Representation of Peary caribou calves as a percentage of all caribou seen, south-central Queen Elizabeth Islands, NWT, 1961-1988

Year	% calves	Total caribou seen	Source
Bathurst Island plus five western satellite islands			
1988	26.7	602	This study
1985	25.5	391	Miller (1987a)
1975	35.4	48	Fischer and Duncan (1976)
1974	10.6	47	Fischer and Duncan (1976)
1974	0.0	84	Miller et al. (1977a)
1961	19.8	257	Tener (1961, 1963)
Bathurst Island[a]			
1988	27.5	396	This study
1985	22.1	244	Miller (1987a)
1981	18.7	107	Ferguson (1987)
Five western satellite islands[b]			
1988	25.2	206	This study
1985	25.9	147	Miller (1987a)

[a]No caribou calves were seen by Miller et al. (1977a); and Fischer and Duncan (1976) and Tener (1961, 1963) do not break down the number of caribou calves seen within the Bathurst, Alexander, Marc, Massey, Vanier and Cameron islands complex.

[b]Not surveyed by Ferguson (1987) in 1981; Miller et al. (1977a) saw no caribou calves on these five islands; and as in footnote (a) regarding Fischer and Duncan (1976) and Tener (1961, 1963).

Table 25

Muskox summer population estimates on a nine-island, south-central Queen Elizabeth Islands complex[a], NWT, 1961-1988

Year	Month	Population estimate[b]	Mean density[c] (· 100 km^{-2})	Source[d]
Nine-island complex (26 896 km^2)				
1988	Jul.	591	2.197	This study
Bathurst Island plus five western satellite islands (19 266 km^2)				
1988	Jul.	521	2.704	This study
1985	Jul.	546	2.834	Miller (1987a)
1975	Jun.	0[e]	--	Fischer and Duncan (1976)
1974	Aug.	246	1.277	Fischer and Duncan (1976)
1974	Aug.	164	0.851	Miller et al. (1977a)
1961	Jun.-Jul.	1161	6.026	Tener (1961, 1963)
Bathurst Island (16 090 km^2)				
1988	Jul.	503	3.126	This study
1985	Jul.	521	3.238	Miller (1987a)
1981	Aug.	208[f]	1.293	Ferguson (1987)
1975	Jun.	0[e]	--	Fischer and Duncan (1976)
1974	Aug.	235	1.461	Fischer and Duncan (1976)
1974	Aug.	164	1.019	Miller et al. (1977a)
1961	Jun.-Jul.	1136	7.060	Tener (1961, 1963)

cont.

Table 25 cont.

Year	Month	Population estimate[b]	Mean density[c] (· 100 km^{-2})	Source[d]
Five western satellite islands (3176 km^2)				
1988	Jul.	18	0.567	This study
1985	Jul.	25	0.787	Miller (1987a)
1975	Jun.	0[e]	--	Fischer and Duncan (1976)
1974	Aug.	11	0.346	Fischer and Duncan (1976)
1961	Jun.-Jul.	25	0.787	Tener (1961, 1963)
One northern satellite island (220 km^2)				
1988	Jul.	0	0.000	This study
1985	Jul.	0	0.000	Miller (1987a)
1975	Jun.	0	0.000	Fischer and Duncan (1976)
1974	Aug.	0	0.000	Fischer and Duncan (1976)
1974	Aug.	0	0.000	Miller et al. (1977a)
1961	--	-	--	
Two eastern satellite islands (7410 km^2)				
1988	Jul.	70	9.447	This study
1985	--	--	--	
1975	Jun.	0	0.000	Fischer and Duncan (1976)
1974	Jul.	104	1.404	Fischer and Duncan (1976)
1961	Jun.	50	0.675	Tener (1961, 1963)

cont.

Table 25 cont.

Year	Month	Population estimate[b]	Mean density[c] (· 100 km^{-2})	Source[d]

[a]Based on the assumption that Bathurst Island serves as the major muskox island within the nine-island, south-central Queen Elizabeth Islands complex; and Alexander, Marc, Massey, Vanier and Cameron islands are five major western satellite islands to Bathurst Island; and Helena Island is the one major northern satellite island to Bathurst Island; and Little Cornwallis and Cornwallis islands are two major eastern satellite islands to Bathurst Island.

[b]Population estimates have been recalculated from the data sources, when necessary to fit the groupings presented in this table.

[c]Mean densities for 1961 to 1981 were recalculated, using the landmass size presented in the heading of each of these groupings to be in agreement with calculated sizes of land bases used in 1985 and 1988.

[d]Based on recalculation of data from these sources, whenever necessary to put in agreement with groupings and landmass sizes used in this report.

[e]Fischer and Duncan (1976) saw 69 muskoxen off transect in June 1975.

[f]Ferguson (1987) actually saw 229 muskoxen but estimated only 208.

Table 26

Summary of relative ranking by survey stratum of muskoxen by relative importance of percentage of total muskoxen seen on island (on and off transect), by relative importance of proportion of total estimated number of muskoxen for the entire island and by relative importance of the mean density by survey stratum, Bathurst Island, NWT, summers 1961-1988

Year	Relative importance - rank[a] Stratum I	Stratum II	Stratum III	Source
1988	2nd (2nd) 1st	3rd (3rd) 3rd	1st (1st) 2nd	This study
1985	2nd (1st) 1st	3rd (3rd) 3rd	1st (2nd) 2nd	Miller (1987a)
1981	2nd (2nd) 2nd	3rd (3rd) 3rd	1st (1st) 1st	Ferguson (1987)
1975	2nd --[b] --[b]	3rd -- --	1st -- --	Fischer and Duncan (1976)
1974	3rd -- --	2nd -- --	1st -- --	Fischer and Duncan (1976)
1974	3rd (3rd) 3rd	2nd (2nd) 2nd	1st (1st) 1st	Miller et al. (1977[a])
1961	3rd (2nd) 1st	2nd (3rd) 3rd	1st (1st) 2nd	Tener (1961, 1963)

[a]First value equals ranking for the relative importance of the percentage of total muskoxen seen; second value (in parentheses) equals relative importance for the proportion of total number of muskoxen estimated; and the third value equals relative importance of the mean density among the three survey strata (where: 1st = most; 2nd = moderate; and 3rd = least).
[b]Data source does not allow breakdown at survey stratum level.

Table 27

Representation of muskox calves as a percentage of all muskoxen seen, south-central Queen Elizabeth Islands, NWT, 1961-1988

Year	% calves	Total muskoxen seen	Source
Bathurst Island plus five western satellite islands			
1988	11.8	331	This study
1985	18.1	370	Miller (1987a)
1975	10.1	69	Fischer and Duncan (1976)
1974	0.7	135	Fischer and Duncan (1976)
1974	0.0	105	Miller *et al.* (1977a)
1961	9.0	111	Tener (1961, 1963)
Bathurst Island[a]			
1988	12.2	320	This study
1985	17.9	351	Miller (1987a)
1981	16.2	222	Ferguson (1987)
Five western satellite islands[b]			
1988	0.0	11	This study
1985	21.1	19	Miller (1987a)

[a]No muskox calves were seen by Miller *et al.* (1977a); and Fischer and Duncan (1976) and Tener (1961, 1963) do not break down the number of muskox calves seen within the Bathurst, Alexander, Marc, Massey, Vanier and Cameron islands complex.

[b]Not surveyed by Ferguson (1987) in 1981; Miller *et al.* (1977a) saw no muskox calves on these five islands; and as in footnote (a) regarding Fischer and Duncan (1976) and Tener (1961, 1963).

Table 28

Summertime occurrences of Peary caribou in Polar Bear Pass, central Bathurst Island, NWT, 1961-1988, obtained from aerial surveys

Year/month/days	Number caribou seen in area[a]	% of all caribou seen on island	Source
1988/Jul./15-21	11	2.8	This study
1985/Jul./13-25	22	9.0	Miller (1987a)
1981/Aug./10-13	0	0.0	Ferguson (1987)
1975/Jun./25-26	0	0.0	Fischer and Duncan (1976)
1974/Aug./18-25	0	0.0	Fischer and Duncan (1976)
1974/Aug./25-26	41	48.8	Miller et al. (1977a)
1961/Jun.-Jul./19-7	1	0.2	Tener (1961, 1963)

[a]Area equals Polar Bear Pass (ca. 60 km east-west by 20 km north-south from Goodsir Inlet on the east to Bracebridge Inlet on the west.

Table 29

Summertime occurrences of muskoxen in Polar Bear Pass, central Bathurst Island, NWT, 1961-1988, obtained from aerial surveys

Year/month/days	Number muskoxen seen in area[a]	% of all muskoxen seen on island	Source
1988/Jul./15-21	26	8.1	This study
1985/Jul./13-25	29	8.3	Miller (1987a)
1981/Aug./10-13	47	24.9	Ferguson (1987)
1975/Jun./25-26	12	17.4	Fischer and Duncan (1976)
1974/Aug./18-25	29	15.3	Fischer and Duncan (1976)
1974/Aug./25-26	20	19.0	Miller et al. (1977a)
1961/Jun.-Jul./19-7	167	69.0	Tener (1961, 1963)

[a]Area equals Polar Bear Pass (ca. 60 km east-west by 20 km north-south from Goodsir Inlet on the east to Bracebridge Inlet on the west.

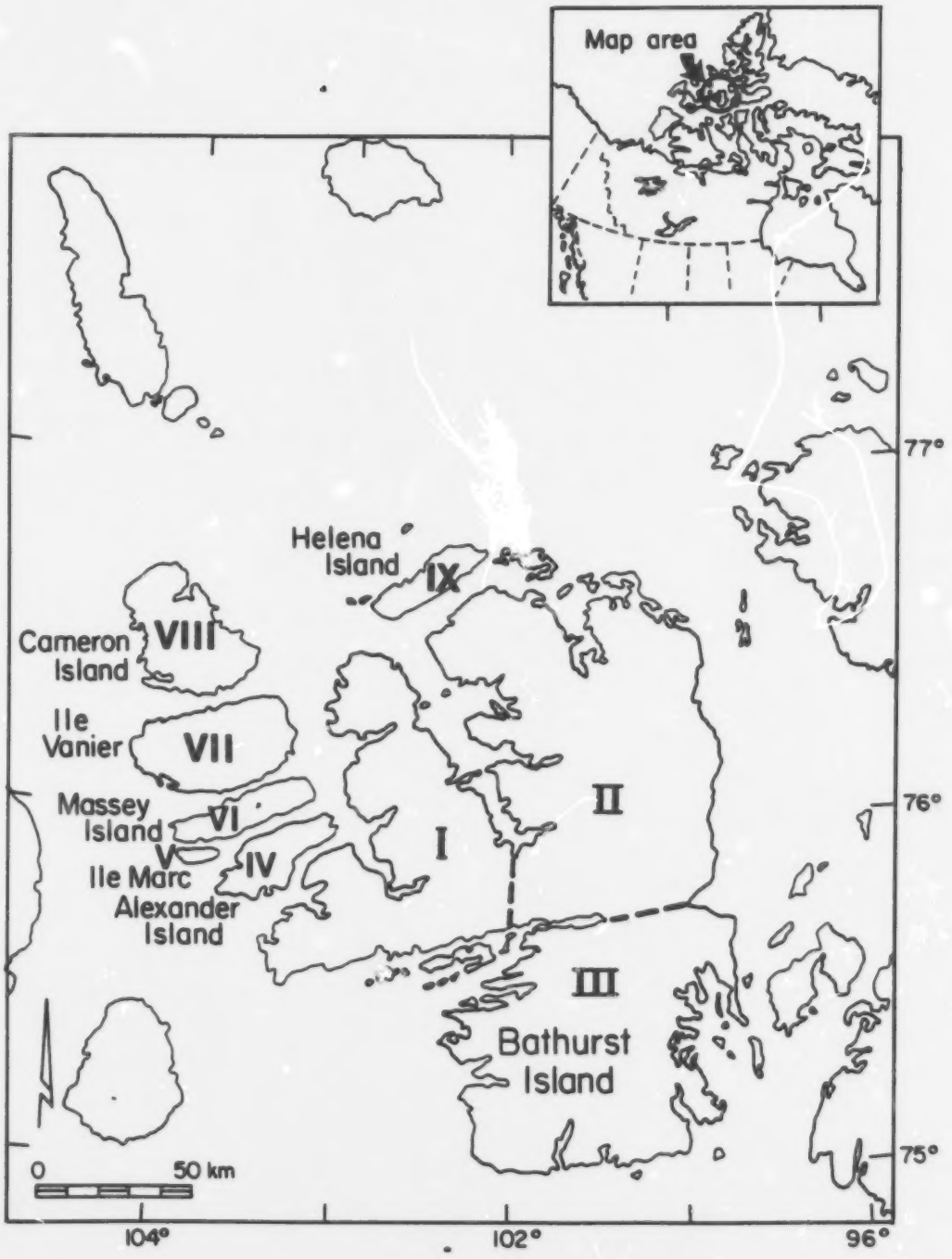

Fig. 1. Locations of nine of the 11 survey strata used in July 1988 aerial survey of nine south-central Queen Elizabeth Islands, NWT

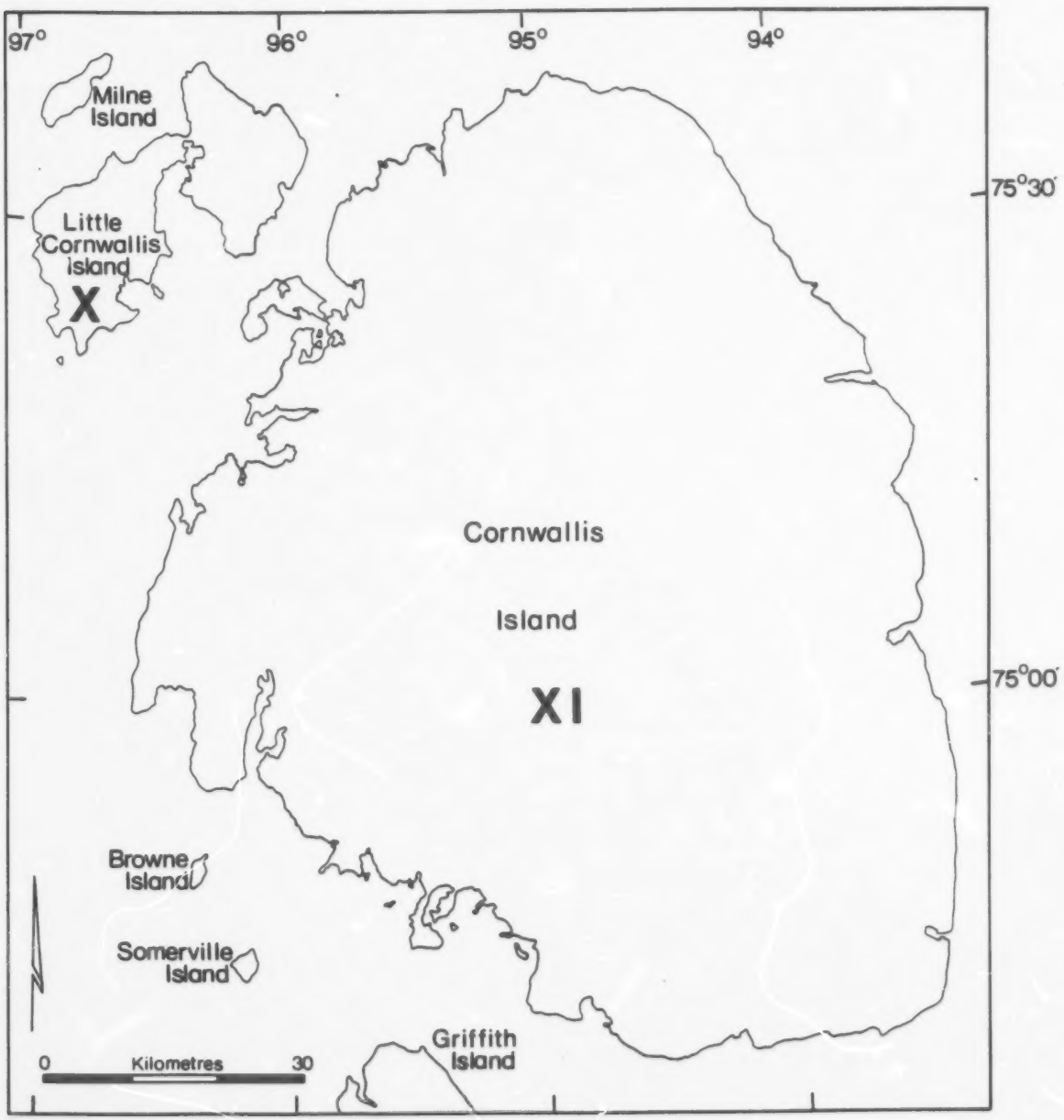

Fig. 2. Locations of two of the 11 survey strata used in July 1988 aerial survey of nine south-central Queen Elizabeth Islands, NWT

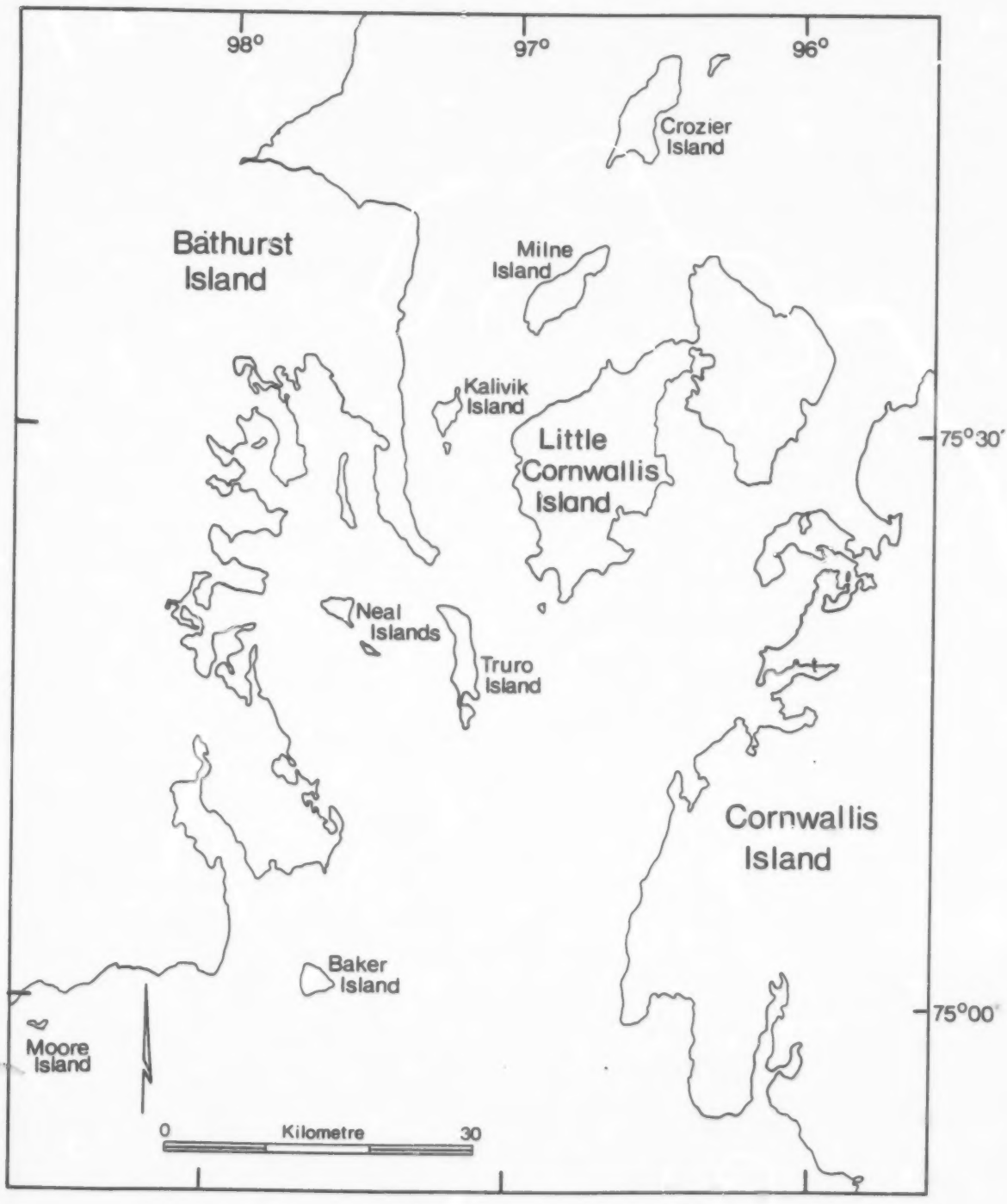

Fig. 3. Locations of seven lesser islands aerially searched in July 1988: Baker and Moore in Intrepid Passage; and Crozier, Kalvik, Milne, Neal and Truro in McDougall Sound

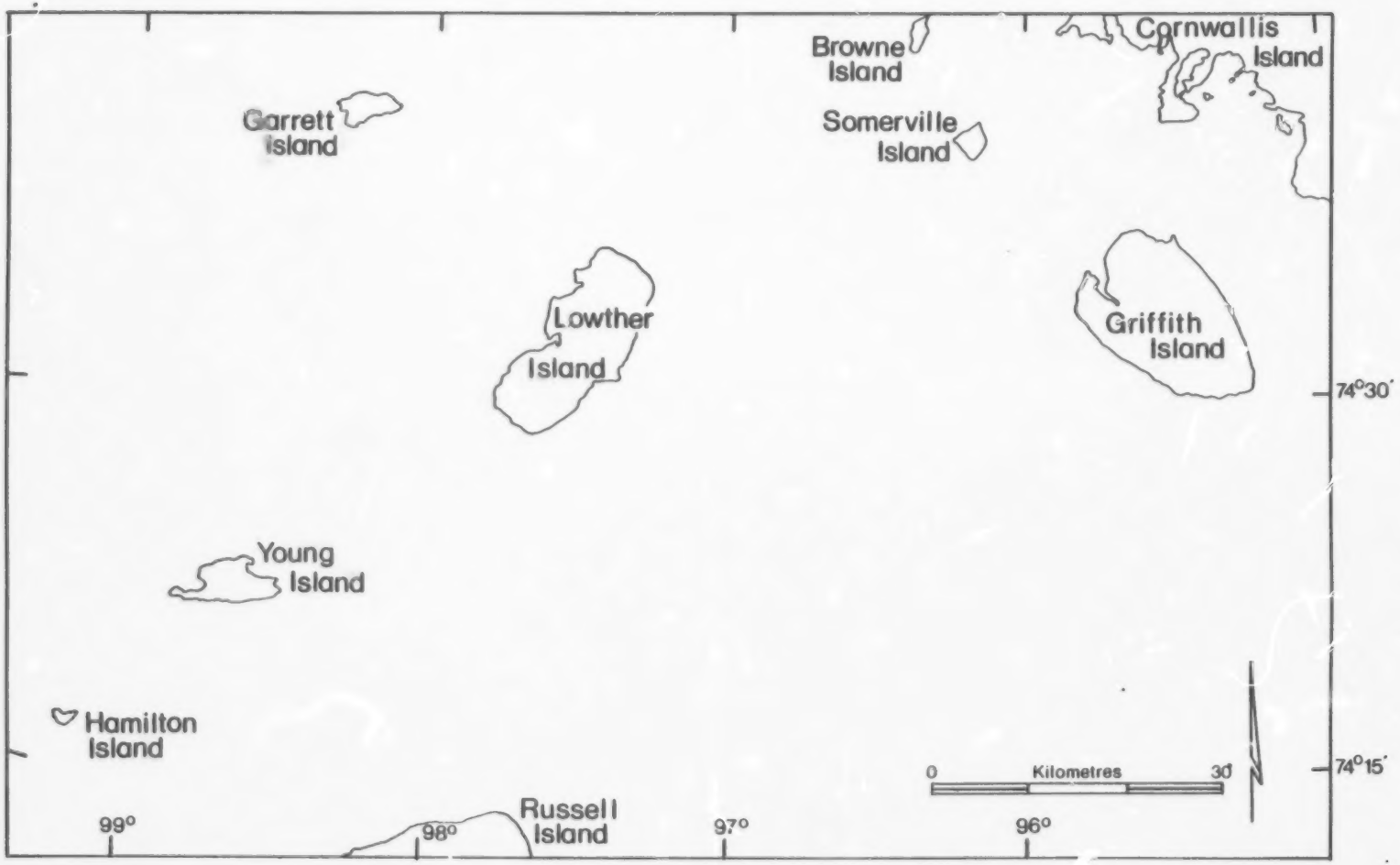

Fig. 4. Locations of seven lesser islands aerially searched in July 1988: Browne, Garrett, Griffith, Hamilton, Lowther, Somerville and Young in Barrow Strait

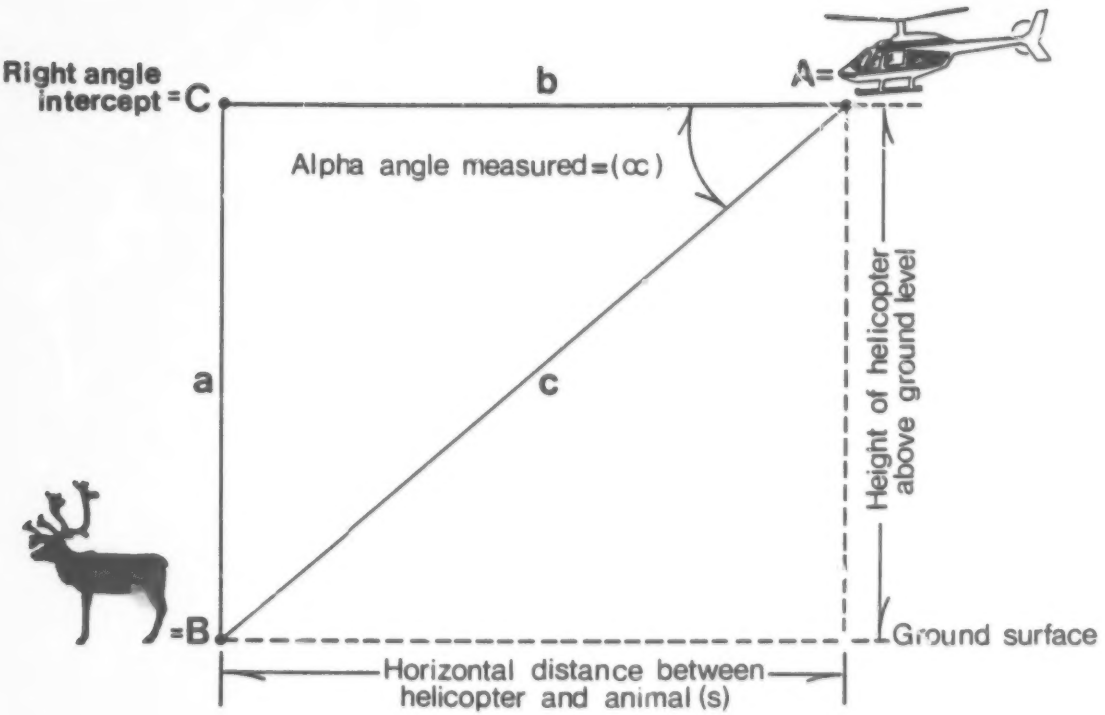

Fig. 5. Schema of angle measured with hand held clinometer for calculation of horizontal right angle distance to animal(s) sighted along line transect

Appendix 1

Distribution of line transects on Bathurst Island by survey stratum from a common baseline at 99°W, NWT, July 1988

Transect number	Distance of transect from baseline by stratum (km)		
	I	II	III
1	west[a] 101.6	west[a] 50.4	west[a] 44.4
2	95.2	44.4	44.4
3	88.9	38.1	38.1
4	82.6	31.8	31.8
5	76.2	38.1	25.4
6	69.8	31.8	19.0
7	63.5	31.8	12.7
8	82.6	25.4	6.4
9	76.2	19.0	BL
10	69.9	12.7	east[a] 6.4
11	76.2	6.4	12.7
12	69.9	east[a] BL	19.0
13	69.9	6.4	25.4
14	63.5	12.7	31.8
15	57.2	19.0	38.1
16	50.8	25.4	38.1
17	44.4	31.8	44.4
18	38.1	38.1	
19	31.8		
20	25.4		

[a]Distances are west or east of the baseline, all line transects were north-south.

Appendix 2

Distribution of line transects on six satellite islands of Bathurst Island, NWT, July 1988

Transect number	Distance of transect from baseline (km)					
	Alexander	Marc	Massey	Vanier	Cameron	Helena
1	east[a] 19.0	east[a] 6.4	east[a] 3.2	west[a] 12.7	west[a] 15.9	west[a] 37.8
2	22.2	9.5	6.4	9.5	12.7	44.1
3	25.4	12.7	9.5	6.4	9.5	50.8
4	28.6	15.9	12.7	3.2	6.4	57.2
5	31.8		15.9	BL[b]	3.2	63.5
6	34.9		19.0	3.2	BL[b]	69.8
7	38.1		22.2	6.4	3.2	
8	41.3		25.4	9.5	6.4	
9	44.4		28.6	12.7	9.5	
10	east[a] 47.6		east[a] 31.8	west[a] 15.9	west[a] 12.7	
11	50.8		34.9	1 9.0	15.9	
12	54.0		38.1	22.2	19.0	
13			41.3	25.4	22.2	
14			44.4	28.6	25.4	
15				31.8		
16				34.9		
17				38.1		

[a]Distances are west and east of the baseline, all line transects were north-south.

[b]The locations of the baselines were as follows: Alexander, Marc, Massey, Vanier and Cameron at 104°W; and Helena at 99°W.

Appendix 3

Distribution of line transects on Little Cornwallis and Cornwallis islands, NWT, July 1988

Transect number	Distance of transect from baseline (km)			
	Little Cornwallis		Cornwallis	
1	west[a]	57.2	west[a]	44.4
2		50.8		38.1
3		44.4		31.8
4		38.1		25.4
5		31.8		19.0
6		25.4		12.7
7				6.4
8				BL[b]
9				6.4
10				12.7
11				19.0
12				25.4
13				31.8
14				38.1
15				44.4

[a]Distances are west or east of the baseline (95°00'W), all line transects were north-south.

Appendix 4

Descriptive accounts of nonsystematic aerial search flight courses with a Bell-206B helicopter, south-central Queen Elizabeth Islands, NWT, June 1988

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8 June 1988 - Off Resolute Bay, Cornwallis Island, enroute to Freemans Cove, SE Bathurst Island. Swung over Baker Island and searched it in its entirety. Followed caribou trails on the sea ice from the NW corner of Baker Island toward N side of Freemans Cove, Bathurst Island. From the fuel cache at Freemans Cove flew N along the SE coast as far as Brooman Point. Then returned S along a flight line about 5 km further inland and then returned to Freemans Cove. Then proceeded along the S coast of Bathurst Island to the SW coast and located fuel cache just S of Hooker Bay on Playfair Point. Then flew N and NW along the SW coast to Alexander Island and located the fuel cache on Alexander. Then proceeded E and SE to Boyer Strait, then S to Bracebridge Inlet and then E to the National Museaum of Sciences, Arctic Research Station (NMS, HARS), in Polar Bear Pass. From there flew SE to Cornwallis Island, then on to Resolute Bay along the S coast of Cornwallis Island (5.6 h flying time - only 14 caribou seen on searches).

13 June 1988 - Off Resolute Bay enroute to Bathurst Island. Continuous fog banks on the sea ice between Cornwallis and Bathurst islands prevented flying over sea ice. Remained on Cornwallis Island, dodging "whiteouts" and made way back to Resolute Bay (1.5 h flying time - no caribou seen).

15 June 1988 - Off Resolute Bay enroute to Bathurst Island, searched Baker Island on way to Freemans Cove for fuel. Then flew W about 1-km inland from the S coast of Bathurst to Allison Inlet. Then returned to Freemans Cove on a line about 3 km N of the coast. From Freemans Cove followed the coast N to Lacy Point, Bass Point, Bateman Bay and Markham Point. Then N about 3 km inland, reaching the coast just S of Black Point. Then along the S shore of Goodsir Inlet, having crossed the inlet, and N again along the coast to about Paine Point. Then inland for approx. 15 km and then S to the NMS, HARS. Then along the S shore of Bracebridge Inlet and then S to Hooker Bay. Then followed the coast S and E back to Freemans Cove. From Freemans Cove N to Truro Island, Brooman Point and Kalivik Island. Then E and NE to Royal Point on Little Cornwallis Island and along the N coast to Templeton Bay. Then S to Wilkes Point and the Marshall Peninsula on Cornwallis Island. Then followed the W coast past Bond Point to Stanley Head, Cape Rosse and along the S coast to Resolute Bay (8.4 h flying time - 1095 caribou seen on searches).

cont.

Appendix 4 cont.

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18 June 1988 - Off Resolute Bay enroute to Bathurst Island, searched Baker Island on the way. Then crossed Bathurst Island E-W from Freemans Cove to a point just N of Mount Bulloch (SW Bathurst). Then NNW across Graham Moore Bay and directly to the fuel cache on Alexander Island. From the fuel cache flew NW to the coast and crossed to Ile Marc, thence N to Massey island. Then E along the S coast of Massey Island around the E end of it and then crossed to Ile Vanier. Then flew along the E side of Ile Vanier, and then turned W along the N coast. Approx. half way to the W end of Ile Vanier turned N to Cameron Island and proceeded to Icoate fuel cache at Maria Point. From there flew N along the W coast to Lyall Point. From Lyall Point returned to the fuel cache. Then S and E across Cameron Island, crossed Erskine Strait to Cape Hooper, then E to Dampier Bay at the S end of Dundee Bight. Then flew E to the E coast, emerging at the mouth of the Walker River. Then flew S and followed the sea ice to a point several kilometers S of the Polaris Mine on Little Cornwallis Island. Then crossed to Cornwallis Island and flew overland to Resolute Bay (6.4 h flying time - 60 caribou seen on searches).

Appendix 5

Individual observations of Peary caribou seen on nonsystematic aerial searches and classified by sex/age classes, south-central Queen Elizabeth Islands, NWT, June 1988

Island	Date June 1988	Sex/age class					
		Bulls	Cows[a]	Calves	Juveniles[b]	Yearlings	Total
Bathurst							
NE[c]	8		1	1			2
	15		6		2	2	10
			5		2	2	9
			1	1			2
			1	1			2
			1	1			2
					2		2
			1	1			2
			1	1	1		3
			1				1
			1	1			2
		3			1		4
		1			1		2
		2					2
			2	1	2		5
NE[c]			1	1			2
	15		1	1			2
					1		1
			2		3	2	7
Subtotal	(8,15)	(6)	(25)	(10)	(15)	(6)	(62)
SE	15	2			2		4

cont.

Appendix 5 cont.

Island	Date June 1988	Sex/age class					
		Bulls	Cows[a]	Calves	Juveniles[b]	Yearlings	Total
			2	1			3
Subtotal	(15)	(2)	(2)	(1)	(2)		(7)
S	15	4			4		8
		1			1		2
			3		2	1	6
			2		3	1	6
					4	2	6
Subtotal	(15)	(5)	(5)		(14)	(4)	(28)
SW	15	3					3
		2					2
			1	1			2
	18	1			2	1	4
		6					6
		2					2
Subtotal	(15,18)	(14)	(1)	(1)	(2)	(1)	(19)
NW[c]	18		4		3	2	9
					1		1
					3		3
			2	2			4
			2				2
					4		4
Subtotal	(18)		(8)	(2)	(11)	(2)	(23)

cont.

Appendix 5 cont.

Island	Date June 1988	Sex/age class: Bulls	Cows[a]	Calves	Juveniles[b]	Yearlings	Total
Baker	8	4					4
	15	2			1		3
	18	2			1		3
Subtotal	(8,15,18)	(8)			(2)		(10)
Alexander	8		2		2	1	5
			2		1		3
	18		3		2		5
					7		7
		1					1
Subtotal	(8,18)	(1)	(7)		(12)	(1)	(21)
Massey	18		5	5	2		(12)
Vanier	18		2		3		(5)
Totals	(8,15,18)	(30)	(55)	(19)	(62)	(14)	(187)

[a]Only those individuals identified as breeding cows.
[b]Includes nonbreeding females or juveniles of either sex.
[c]Coastal area of Bathurst Island.